
IN DEO CONFIDO.

Rec^d from the Binder Sept 6th 1865
G.D.G.

Lectures

on

Physiology

delivered in the St Lawrence School of Medicine at Montreal

BY

George Duncan Gibb MD.

Vol. I.

Order of Delivery of the Lectures

No 1 Proximate Organic Principles
2 Cellular Membrane
3 Adipose Membrane
4 Serous Membranes
5 Mucous Membranes
6 Skin &c, Hair, Nails
7 Cartilage and Fibro Cartilage
8 Bones
9 The Muscles No 1
10 — Do — No 2
11 The Arteries, Veins and Capillaries
12 Blood
13 Circulation No 1

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See Volume 2 for the remainder.

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Memoranda -

The date on the first page of each lecture refers to the time at which it was written, but not delivered -

The next 5 pages, give the periods at which the Lectures were delivered, together with the examinations -

A part of November was lost, because of my absence on my marriage -

The Numbers of the Lectures on Physiology 1 to 46 appear in these 2 Vols, and they correspond to the Numbers in the order of their arrangement -

Those on Pathology No 1 to 28 appear in a separate volume from these two, and is properly labelled -

Order in which the following Lectures were delivered during the session 1851 – 1852

		1851		
1	Tuesday	4	Novem	Comparative Anatomy no 1
2	Wednesday	5	"	— do — do no 2
3	Monday	17	"	1 Proximate Principles
4	Tuesday	18	"	2 Cellular Membrane
5	Wednesday	19	"	3 Adipose do
6	Thursday	20	"	4 Serous do
7	Friday	21	"	5 Mucous do
8	Saturday	22	"	Comparative Anatomy no 3
9	Monday	24	"	6 Skin &c
10	Tuesday	25	"	examination
11	Wednesday	26	"	7 Cartilage
12	Thursday	27	"	8 Bones
13	Friday	28	"	9 Muscles no 1
14	Saturday	29	"	Comparative Anatomy no 4
15	Monday	1	"	examination
16	Tuesday	2	"	10 Muscles no 2
17	Wednesday	3	"	elections – no lecture
18	Thursday	4	"	elections – no lecture
19	Friday	5	"	11 Arteries
20	Monday	8	"	12 Blood
21	Tuesday	9	"	13 Circulation 1

ure	22	Wednesday	10	December	14 Circulation 2
1852	23	Thursday	11	"	15 Lymph
	24	Friday	12	"	16 Absorption
	25	Monday	15	"	examination
1	26	Tuesday	16	"	17 Secretion
2	27	Wednesday	17	"	18 Respiration
	28	Thursday	18	"	19 Respiration
	29	Friday	19	"	examination

Christmas Recess –

				1852	
	30	Monday	5	January	20 Animal Heat
3	31	Tuesday	6	"	21 Motion
	32	Wednesday	7	"	22 Digestion No 1
	33	Thursday	8	"	23 Digestion No 2
	34	Friday	9	"	24 Digestion No 3
	35	Monday	12	"	examination
	36	Tuesday	13	"	25 Digestion No 4.
4	37	Wednesday	14	"	26 Digestion No 5
	38	Thursday	15	"	27 Kidneys
	39	Friday	16	"	I gave no lecture
	40	Monday	19	"	examination
	41	Tuesday	20	"	28 Nervous Syst 1
	42	Wednesday	21	"	29 Nervous Syst 2
	43	Thursday	22	"	30 Nervous Syst 3
	44	Friday	23	"	31 Nervous Syst 4

1852

45	Monday	26	January	Examination
46	Tuesday	27	"	32 Nervous Syst 5
47	Wednesday	28	"	33 Nervous Syst 6
48	Thursday	29	"	34 Nervous Syst 7
49	Friday	30	"	35 Nervous Syst 8
50	Monday	2	February	examination
51	Tuesday	3	"	36 Voice
52	Wednesday	4	"	$36\frac{1}{2}$ & $37\frac{1}{2}$ Speech & Taste
53	Thursday	5	"	37 Smell & Microscope
54	Friday	6	"	40 Ear No 1
55	Monday	9	"	Examination
56	Tuesday	10	"	41 Ear No 2
57	Wednesday	11	"	42 Generation No 1
58	Thursday	12	"	43 Generation No 2
59	Friday	13	"	44 Generation No 3
60	Monday	16	"	Examination 9
61	Tuesday	17	"	45 Generation No 4
62	Wednesday	18	"	38 Eye No 1
63	Thursday	19	"	39 Eye No 2
64	Friday	20	"	46 Touch -
65	Monday	23	"	Examination
66	Tuesday	24	"	1 Serous Membranes
67	Wednesday	25	"	Ash Wednesday - No lecture
68	Thursday	26	"	2 Pericardium
69	Friday	27	"	3 Arachnoid

1862

70	Monday	1 March	Examination
71	Tuesday	2 "	4 Pleura
72	Wednesday	3 "	5 Peritoneum
73	Thursday	4 "	Gave this hour to Macdonnell
74	Friday	5 "	6 Mucous Membranes
75	Monday	8 "	examination
76	Tuesday	9 "	7 Mouth
77	Wednesday	10 "	8 Pharynx
78	Thursday	11 "	gave no lecture
79	Friday	12 "	9 Stomach No 1
80	Monday	15 "	examination
81	Tuesday	16 "	10 Stomach No 2
82	Wednesday	17 "	St Patricks day. No lecture
83	Thursday	18 "	11 Intestines
84	Friday	19 "	12 Small Intestines
85	Monday	22 "	examination
86	Tuesday	23 "	13 Large Intestines
87	Wednesday	24 "	14 Larynx
88	Thursday	25 "	15 Trachea
89	Friday	26 "	Gave this hour to Macdonnell
90	Monday	29 "	examination
91	Tuesday	30 "	16 Dilated Bronchi
92	Wednesday	31 "	17 Urethra.

1852

93	Thursday	1	April	Gave no Lecture
94	Friday	2	"	18 Bladder
95	Monday	5	"	examination
96	Tuesday	6	"	19 Ureters
97	Wednesday	7	"	20 Kidneys
98	Thursday	8	"	Holy Thursday - no Lect
99	Friday	9	"	Good Friday - do
100	Monday	12	"	Easter Monday - do
101	Tuesday	13	"	No audience
102	Wednesday	14	"	21 Veins
103	Thursday	15	"	22 Arteries
104	Friday	16	"	23 Aneurism no 1
105	Monday	19	"	24 Aneurism no 2
106	Tuesday	20	"	25 Pulmy Hemorrhage
107	Wednesday	21	"	Gave no lecture
108	Thursday	22	"	26 Pneumonia
109	Friday	23	"	St Georges Day
110	Monday	26	"	27 other Pneumonias
111	Tuesday	27	"	I had an operation
112	Wednesday	28	"	28 {Emphysema / my last lecture
113	Thursday	29	"	
114	Friday	30	"	

1851 – 2

November 4 weeks
December 3 "
January 4 "
February 4 "
March $4\frac{1}{2}$ "
April $4\frac{1}{2}$ " 24 weeks
4 lectures per week
Total 96 lectures
24 examinations

Grand total 120, for each examination always counts as a lecture – But deduct for my Introductories 4, leaving my present course 92 –

Proximate Organic Principles

G. D. Gibb M.D.

May 24. 1857

This lecture was too short - Hereafter write down the Analyses before the class on the board, and extend some of the lecture - 2 or 3 pages -

Take more time with the experiments.

To illustrate

Albumen of blood and of an egg

Dried blood - An egg

Preparations of fibrine

All the tests for albumen

Spirit lamp	Nitric acid
tubes	Acetic acid
tube frame	Prussiate Potash
	Corrosive Sub
	Sulf Copper

Gelatine Tinct Galls -

Glue

Isinglass

Organised and Unorganised bodies. The various objects in nature have been divided into unorganised and organised bodies. All elementary principles and their mineral compounds are included in unorganised bodies. Organised bodies again include vegetables and animals. The essential elements of these are H. C. O & N. Besides these are other principles minute in quantity, but still not so essential to the existence of organised bodies, they are

S. P. Cl. Fl. Fe. K. Na. Ca. Mg
Si. Mang. Al. Cu.

mention where each is found –

Proximate Principles; Secondary organic Compounds.

Animal bodies are composed of solids & fluids. The former constitute the muscles, bones and viscera; the latter include the Blood, Chyle, Lymph & the secretions. The solids compose but a small part of the body, whilst the fluids compose the greater portion, being more than 4/5. Blumenbach possessed the Mummy of a full grown Guanche (the aboriginal inhabitants of Teneriffe) presented him by Sir Joseph

Banks, which weighed only seven pounds and a half including muscles, bones &c.

Of the fluids Water is the most important element. It constitutes fully 4/5 of the blood, the nutrient fluid of the body. The loss of water is in the lower animals productive of death, whilst some of the small infusoria, in which from evaporation of the watery constituents, all appearances of life may have vanished, will regain their vitality, on water being supplied to them. It holds many substances in solution, and conveys these substances to the various structures and organs of the body. In the Chemical department of the body, it plays a most important part. These properties of water will be fully shown in the lectures connected with the subjects, in which these different Functions will be described.

By Physiology we classify and arrange them according to their properties and characters, and by Chemistry we resolve them into their proximate principles, by which, we mean, that we resolve them into a condition but one degree removed from the organised structure, of which the blood contains some in solution.

These proximate principles are combined generally with other principles which are called, the incidental principles; these are sulphur, phosphorus, and other simple substances.

These proximate principles are to be distinguished from another class of substances, which are termed the Secondary organic compounds.
So that by Chemistry, we resolve the entire of the solids and fluids into three classes.
1 - The Proximate Principles — 2 The Secondary organic Compounds — 3 Incidental Elements. —
The true Proximate principles are those substances which are first obtained from the organized structures. In the vegetable kingdom, gluten, starch, lignine. In the animal kingdom - Albumen, fibrine, & Caseine, from which by subsequent combinations the secondary organic elements are obtained.

Thus, by boiling starch in dilute acids, it becomes converted into a kind of gum, and starch sugar. By placing yeast in contact with sugar, the latter is converted into alcohol and carbonic acid, without the yeast affording it any of its chemical constituents; and in the germination of barley, or of the potatoe, a peculiar substance is formed, the contact of which with the starch of the barley or potatoe converts it into sugar.

Proximate Principles		Secondary organic Compounds
Albumen Fibrine Caseine	} Compounds of Proteine	Urea; Uric or Lithic Acid; } in the Urine
Gelatine		Cholesterine; in the Bile.
Chondrine		Biliary matters.
Elaine		Pepsine; in the Gastric Juice.
Stearine		Sugar of Milk.
Margarine		Lactic Acid.
Haematosine		
Globuline		

<u>Albumen</u>. So called from the white colour of the <u>ovalbumen</u> of eggs. It exists in the human body in two states; the fluid and the solid. In its fluid form it is dissolved in the serum of the blood, & some of the secretions; and solid, forming certain of the tissues, which are in consequence called the albuminous tissues. Such as the brain, spinal cord and the nerves, and the mucous membranes; it is also found in muscles, and in the aqueous & vitreous humours of the eye. It is also found in serum and pus.

<u>Albumen may be coagulated</u> by certain reagents, but it does <u>not possess any power of self coagulation</u>.

1st <u>Evaporation</u>. by which its water is driven off –

(shown specimen)

Heat at 140° and 150° Coagulates Albumen. insol in water.
The Mineral Acids especially Nitric Acid
Alcohol
Corrosive Sublimate. This poison was first Combated by albumen at the suggestion of Orfila. Peschier states that the white of one egg, will neutralise 4 grs of Corrosive Sublimate. It converts it partly into Calomel.
Ferro Cyanide of Potassium. It requires a little acetic acid to be added to the solution containing the albumen.
Tannin is also a test for albumen
This proximate principle is often carried off by the kidneys. Albumen is soluble in caustic alkalis.
Sulphur is contained in albumen; this may be seen by silver becoming tarnished from white of egg.
Analysis of Albumen by Mulder

Nitrogen	15.83
Carbon	54.84
Hydrogen	7.09
Oxygen	21.23
Phosphorus	0.33
Sulphur	0.68
	100.00

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Fibrine. Principal constituent of the muscles - here it occurs in the solid form: it occurs in solution in the serum of the Blood, forming with that fluid, the Liquor Sanguinis; it also is present in the lymph and in the chyle. It constitutes a great part of the exudation which forms on serous membranes as the result of inflammation (the coagulable lymph).

Fibrine sometimes occurs in dropsical effusions.

Fibrine differs from the other proximate principles in its powers of spontaneous coagulation. Blood drawn from a vein, separates into 2 portions, the Crassamentum or clot the solid portion, and the serum the fluid portion. The Buffy coat or inflammatory crust is a nearly colourless fibrine. It occurs from an unusual aggregation of the red particles together, their more speedy precipitation, some of the fibrine coagulating on the surface without enclosing the colouring matter.

How to procure Fibrine. Cut the crassamentum into slices and wash them - by stirring blood, with twigs - Mullers plan is to filter the frogs blood - the globules of which are so much larger than those of the human subject, that they will be arrested in their passage through the filtering paper and allow, in this manner, the fibrine to percolate in almost a pure state.

Fibrine also collects, and coagulates spontaneously in the cavities of the heart, in an artery upon which we place a ligature, and in the sacs of aneurisms —

Pure fibrine is <u>white</u>, <u>tasteless</u>, & inodorous: it tears into thin laminae which are transparent, and it is remarkably elastic. It also dries, but regains its weight again when exposed to water.

It is insoluble, both in cold & hot water, in alcohol & in ether - by long continued boiling in water it becomes soluble - Strong acetic acid, converts it into a mass like jelly - all the alkalies dissolve fibrine.

<u>Fibrine</u> is dissolved, by cold concentrated muriatic acid, and if kept in a cool temperature for 24 hours, it acquires an indigo blue colour.

Albumen treated in the same manner assumes a violet colour -

<u>Caustic Potash</u>, <u>common salt</u>, & <u>Carb of Potash</u> prevent the coagulation of the blood -

Analysis of Fibrine by <u>Mulder</u>

Nitrogen ———	15. 72
Carbon ———	54. 56
Hydrogen ———	6. 90
Oxygen ———	22. 13
Phosphorus ———	0. 33
Sulphur ———	0. 36
	100. 00

<u>Caseine</u>. Has properties in common with albumen & fibrine. It occurs abundantly in Milk. <u>Curds</u> are composed of Caseine & the acid employed to coagulate the Milk.

In addition to heat, we must always add a little acid to precipitate the Caseine.
Sulphuric acid added to skimmed milk, makes a Sulphate of Caseine. Digest this with water and Carbonate of lime and the Caseine being set free, may be obtained by evaporation.

Rennet coagulates by virtue of the peculiar matter the pepsine. Rennet coagulates every particle of Caseine contained in milk.

In the coagulated state it is not soluble in water, but is so in liquor potassae. It is not precipitated by heat alone; but as before stated it requires some acid along with heat.

Acetic acid will coagulate Caseine, but does not do so with albumen.
Caseine contains Sulphur, but no Phosphorus.

Analysis of Caseine from Mulder –

Nitrogen	15.95
Carbon	55.10
Hydrogen	6.97
Oxygen	21.62
Sulphur	0.36
	100.00.

Proteine. If albumen, or fibrine, or caseine be dissolved in a moderately strong solution of caustic potash, and exposed for some time to a high temperature, it becomes decomposed; and if acetic acid be now added, a precipitate takes place of

a gelatinous transparent matter. This substance was discovered by Mulder, who gives as its analysis

Nitrogen ——	16.01
Carbon ——	55.29
Hydrogen ——	7.00
Oxygen ——	21.70
	100.0

Besides the ultimate elements of Albumen, Fibrine & Caseine, which have been fully given, we find that they are in combination –

Albumen contains – Phosphates & sulphates of earths and alkalies, and Chloride of Sodium.

Fibrine Phosphate of lime –

Caseine Phos of lime in the proportion of 6.24 per cent

Uses of the Phosphate of lime in Milk is to supply the earthy matter of the bones in the infant –

A Proteine in all its properties resembling that which forms the basis of the animal proximate principles can be obtained from vegetable matter –

Gluten is a vegetable fibrine – Albumen can be obtained from Cauliflowers, Asparagus & mangel-wurzel which cannot be distinguished from that of white of egg – or of serum. This is vegetable albumen –

And a substance similar to Caseine can be obtained from peas, beans and ~~their~~ other leguminous substances.

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Liebig states, "that the chemical analysis of these 3 substances, has led to the very interesting result, that they contain the same organic elements, united in the same proportions by weight; and what is still more remarkable, that they are identical in composition with the chief constituents of blood, animal fibrine and albumen. They all 3 dissolve in concentrated muriatic acid with the same deep purple colour; and even in their physical characters, animal fibrine and albumen are in no respect different from vegetable fibrine and albumen."

Gelatine is intimately combined with the substances into the composition of which it enters, and artificial means must be employed to separate it from them.

Boiling will remove it from bone, tendon, or true skin; it is then in solution, but as soon as the liquid cools it becomes solid again.

It occurs in the white textures, as white fibrous tissue, the areolar tissue, skin, serous membranes, bone. Glue prepared from hides. Isinglass (another form of gelatine) is procured from the swimming bladder of the Sturgeon.

When dry, gelatine is hard, transparent, colourless & odourless, and without taste. It softens in cold and melts in hot water. It is insoluble in alcohol ~~and~~ or ether, readily soluble in dilute acids and alkalies. Test - Tannin or Tincture

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of galls, throw down tanno-gelatine. It may be precipitated in 5000 times its weight of water. The process of tanning leather results from the affinity of gelatine for tannin. The skins of the animals having been first freed from cuticle and hairs by soaking in lime-water, are tanned by submitting them to the action of infusion of oak-bark.

Analysis of gelatine by Mulder.

Nitrogen	18.350
Carbon	50.048
Hydrogen	6.477
Oxygen	25.125
	100.000

to which may be added some inorganic material, chiefly phosphate of lime.

Dr Prout considers gelatine in animals to be the counterpart of the saccharine principles of plants; it being distinguished from all other animal substances by its ready conversion into sugar, by a process similar to that by which starch may be so converted.

Chondrine. This resembles gelatine in many respects. It is obtained by boiling, from the articular cartilages and from the cornea; also from the temporary cartilages prior to ossification. When the solution cools, it coagulates and then closely resembles glue. It differs from gelatine in not being precipitated by Tannin, and in yielding

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precipitates to acetic acid, alum, acetate of lead, & the protosulphate of Iron; which do not disturb a solution of gelatine.

Analysis of Chondrine by Mulder -

Nitrogen	14.44
Carbon	49.96
Hydrogen	6.63
Oxygen	28.59
Sulphur	0.38
	100.00

Elaine, Stearine and Margarine are proximate principles of fat, and are found also in the brain and nerves. Stearine is not present in the human fat, it abounds in the fat of the Cetacea.

Haematosine and Globuline are the colouring matters of the blood: they are both allied to albumen and globuline is regarded as a compound of proteine.

Cell Theory - All the tissues of the body, according to Schwann either originate from, or consist of cells. Before Schwann had commenced his investigations, Schleiden had shown that the entire Class of Cellular plants in the vegetable Kingdom consisted only of cells; many of them formed solely of homogeneous cells strung together, some of even a single cell - Now Schwann in the course of his investigations pointed out the similarity between some individual

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animal and vegetable tissues. Every cell however in the animal structure is not ~~however~~ an analagous structure to a vegetable cell. An analogy between the cells of animal tissues and the same elementary structure in vegetables can only be drawn with certainty in one of the following ways:

1st By showing that a great portion of the animal tissues originates from or consists of cells, each of which must have its particular wall, in which case it becomes probable that these cells correspond to the cellular elementary structure universally present in plants.

2nd By proving, with regard to any one animal tissue consisting of cells, that in addition to its cellular structure, similar forces to those of vegetable cells are in operation in its component ~~parts~~ cells. *

Schwann conjectured that the cellular formation might be widely extended, perhaps a universal principle for the formation of organic substances. By further examination he constantly found this principle of cellular formation more fully realized. The germinal membrane was soon discovered to be composed entirely of cells, and shortly afterwards cell-nuclei, and subsequently also cells were found in all the tissues of the animal body at their origin, so that he concluded that all tissues consist of cells, or are formed by various modes from cells. A proof of the analogy between animal & vegetable cells was thus afforded.

* Schwann page 6.

#

The *nuclei* have been named *cytoblasts*, because they appear to form the cells (κυτος, cell; βλαστεω, to produce); and the granular deposit in which these changes are produced is called the *cytoblastema*.

The simplest and most elementary organic form therefore, with which we are acquainted, is that of a cell, containing another within it (nucleus), which again contains a granular body (nucleolus). #

This appears from the interesting researches of Schleiden and Schwann to be the primary form which organic matter takes when it passes from the condition of a proximate principle, to that of an organised structure. The most important and abundant proof as to the existence of a cell is the presence or absence of the nucleus.

To describe more particularly Cells, Primary cells, or Elementary cells, they are vesicles or scales of larger average size than nuclei, but like them, composed in the normal state, of membranous cell-walls, with, usually, liquid contents, and generally round or oval.

The cell wall never presents any appearance of structure: it appears to be sometimes a proteine-substance as in blood cells; sometimes a horny matter, as in thick and dried cuticle. In almost all cases (the dry cells of horny tissue, perhaps, alone excepted) the cell wall is made transparent by acetic acid, which also penetrates through it and distends it, so that it can hardly be discerned. But in such cases the cell-wall is usually not dissolved; it may be brought into view again by nearly neutralising the acid with soda or potass.

In some instances, the most developed state of a cell is that in which it has no nucleus, as in the mammalian blood-corpuscules, in which as will be described,

the substance of the nucleus of the lymph- or chyle corpuscle is gradually all appropriated and changed to the contents of the blood-corpuscle. But in other instances, especially in old cells, as in those of the nails, the outer layers of epidermis, and the adipose tissue, the nucleus may disappear, wasting away; and this is probably always a sign of degeneration of the tissue, for a similar wasting of nuclei is commonly observed in all tissues in the state of fatty degeneration.

With the exceptions just mentioned, all the cells of the human body appear to contain nuclei. Sometimes the nucleus nearly fills the cavity of the cell, as in lymph & chyle corpuscules, in which the cell wall lies so close round the nucleus, that it can hardly be seen till it is raised up by water or acetic acid insinuating itself between it and the nucleus; and such is the proportion between the nucleus and cell in young epidermis-cells; but more often the nucleus has a diameter from 1/4 to 1/10th less than the cell.

The simplest shape of cells and that which is probably the normal shape of the primary cell, is oval or spheroidal, as in cartilage cells and lymph corpuscules; but in many instances they are flattened and discoid, as in the blood corpuscules or scale like as in epidermis and tesselated epithelium. By mutual pressure they may become many sided, as the pigment cells of the choroidal pigmentum nigrum and in close textured adipose tissue; they may assume a conical or cylindriform or prismatic shape, as in the varieties of cylinder epithelium and the enamel tubes; or be caudate as in certain bodies in the spleen; they may send out exceeding fine processes in the form of vibratile cilia or larger processes with which they become stellate,

r variously caudate, as in the large nerve or ganglion corpuscules and the epithelium of the choroid plexuses.

The Contents of cells, including under this term all but their nuclei, are almost infinitely various, according to the position office, and age of the cell. In adipose tissue they are the oily matter of the fat, the mixture of margarine & oleine; in gland cells the contents are the proper substance of the secretion, bile, semen, &c as the case may be; in pigment cells they are the pigment granules that give the colour; and in the numerous instances in which the cell contents can be neither seen because they are pellucid, nor tested because of their minute quantity, they are yet, probably, peculiar in each tissue, and constitute the greater part of the proper substance of each. Commonly when the contents are pellucid, they contain granules which float in them; and when water is added and the contents are diluted the granules display an active molecular movement within the cavity of the cell. Such a movement may be seen by adding water to mucus or pus corpuscules, or to those of lymph. In a few cases the whole cavity of the cell is filled with granules; it is so in yelk cells and milk corpuscules, in the large diseased corpuscules often found among the products of inflammation, and in some cells when they are the seat of extreme fatty degeneration. The peculiar contents of cells may be often observed to accumulate first around or directly over the nuclei, as in the cells of black pigment, in those of melanotic tumours, and in those of the liver during retention of bile.

Intercellular substance is the material in which, in certain tissues, the cells are imbedded. Its quantity is very variable. In the finer epithelia, especially the columnar epithelia on the mucous membrane of the intestines, it can be just seen filling the interstices of the close-set cells; here it has no appearance of structure. In cartilage & bone it forms a large portion of the whole substance of the tissue,

and is either homogeneous and finely granular or osseous, or as in fibro cartilage, resembles tough tendinous tissue. In some cases, the cells are very loosely connected with the intercellular substance, and may be nearly separated from it as in fibro cartilage; but in some their walls seem amalgamated with it.

Of the Permanent tissues of the Animal body, taking cells as the Basis of all the Tissues, the following is Schwann's classification.

Class I. Isolated, independant cells.

To this class the cells in fluids, pre-eminently belong.

1 Lymph-corpuscles	3 Mucus-corpuscles
2 Blood do	4 Pus - do

Class II. Independant cells united into continuous tissues.

such as

1 Epithelium	4 Hoofs
2 The pigmentum nigrum	5 Feathers
3 Nails	6 Crystalline lens

Class III. Tissues or cells in which the cell walls have coalesced with each other, or with the intercellular substance.

1 Cartilage and Bone
2 The teeth. (The substantia propria (ivory) of.)

Class IV. Fibre-cells, or tissues, which originate from cells that become elongated into bundles of fibres.

1 Areolar (areolar) tissue.
2 Fibrous tissue.
3 Elastic tissue.

Class V. Tissues or cells, in which both the cell-walls and cavities have coalesced.

1 Muscle.
2 Nerves.
3 Capillary vessels.

Cellular Membrane

H Gibbons

29th May 1857

Use the Microscope -
Add 4 pages to the lecture -

To illustrate

Cellular tissue in spirit
— d — dry
drawing of areolar tissue Todd p 74
d — d — dry d— p 76
Use Microscope -

Cellular Membrane - is the most generally diffused and the most important of all the structures in the Animal economy - It forms not only a covering for the larger organs, but enters intimately into all their structures, it serves to retain them in their different situations and at the same time to separate them from adjacent parts. This membrane is so very essential to the frame of all animals that it would still retain the shape of the body were all other parts removed from the animal.

It is a soft spongy tissue, semitransparent, almost colourless when examined in situations where it is very thin, but where it is deposited in denser layers, it has a white appearance. No matter in what situation of the body we examine it, we shall find it presenting nearly the same characters throughout.

It has been described by various writers under different denominations, such as the cribrous, mucous glutinous, intermediate, areolar, reticulated, laminar, and filamentous substance.

We should study this structure 1st as it presents itself, filling up the cavities and interstices of the body, and 2nd - as it occurs, when intimately enclosing important organs, and sending processes or septa into their substance, by which means their particles are firmly bound down in their proper relative position, and the outline and form of the organ itself retained. This arrangement has merely convenience to recommend it, for the membrane itself is in reality identical in every respect under all circumstances.

The first division has been termed, the external or common cellular tissue (textus cellularis intermedius

sen laxus). The principal use of this form, is to fill up portions of cavities of the body, not occupied by more important parts, and to allow of easy motion in parts whose functions require the frequent change of position. Thus we find that the axilla, groin and ham are filled up with abundance of loose cellular membrane. And in the eyelids, the preputium penis, and in different parts of the face and neck, along the course of the vessels, and in the mamma, we also find a great quantity of this lax tissue. In some parts however it assumes a much denser form than in others, as for instance in the sole of the foot, in the palm of the hand, and along the mesial line of the body. In this latter situation it is particularly dense and compact, except along the middle of the neck where it is particularly loose, to admit of the muscles contracting and relaxing without restraint. In the thorax, the cellular tissue occupying the anterior and posterior mediastinum is also exceedingly loose, and so is that in the perineum and scrotum. Within the spinal canal it is rather dense whilst in front of the vertebrae it is equally loose. Within the cranium it is both scanty and dense. Within the abdomen and chest it is very abundant and serves as a bed upon which the important organs contained within these regions rest, as on a cushion. And generally speaking the more important the viscus, the more is it surrounded and protected by this loose cellular tissue. As before mentioned however, the brain forms an exception to this rule.

This membrane is every where continuous and can be easily traced from any situation in the body to another even the most distant. Thus the cellular

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lining the thorax, can be readily demonstrated, to pass up along the vessels and muscles to the neck there to become continuous with that lining that part of the body, it can be traced along the aorta, the oesophagus and behind the sternum, and it can also be shown to descend behind the Diaphragm into the abdomen whence it escapes through the sciatic notch, the foramen ovale and the inguinal and crural rings, and so connects itself with that found in the lower extremities - From the cranium it passes through the different foramina which give exit to the vessels & Cerebral nerves and from the Vertebral canal it escapes through the intervertebral holes -

2nd When we examine it surrounding important organs, we find that besides affording a strong investment, it also sends into its interior, from every point of its surface, innumerable processes, from which others again pass off in every direction, so as to resemble closely the structure of a sponge - Within the cells thus formed the proper parenchyma is safely lodged, and on whose surfaces the arteries, veins, nerves and lymphatics of the organs course in every direction and are dispersed throughout its entire extent.

Those organs which are hollow have cellular membrane only on one side - and we only find it in connection with the attached surfaces of the mucous and serous membranes, and on the under surface of the skin.

In the muscles, it not only enters in between each, and forms a line of demarcation between them, but it actually sends in processes to surround

each individual fibre of the muscle, and from these, secondary processes are sent off & surround the minutest fibrillae of the muscle. In the same way, the lobules and even the granules of the glands are completely surrounded and bound together by this membrane -

Those organs which are composed of several layers, contain between each, folds of cellular membrane.

In the lungs, the different lobes, lobules and cells are divided by layers of cellular membrane, which in proportion to the minuteness of the cell or lobule, assumes either a firm or delicate consistence; thus the membrane covering the small arteries and veins is infinitely more delicate than that covering the trunks, with which these minute vessels are connected.

In proportion too, to the amount of motion enjoyed by an organ, we find the cellular membrane presenting itself, not only in greater abundance, but also in a more compact and dense form. This accounts for the quantity and strength of that surrounding the large muscles -

Ligaments, (whose structure is most compact and intimate) present little, if any loose cellular membrane: nor, can we discover any free membrane in the structure of bones, tendons or cartilage, or the Teeth - In the substance of the Brain, also, it does not exist, excepting around the vessels of two or three removes from the Capillaries - (Todd.)

In the heart, too, it is very scantily distributed. Here it is not necessary, for from the intimate interlacement of the fibres of the Muscle, the presence of cellular tissue is not required -

But the role which cellular membrane plays in the animal economy has not yet been fully stated. It is it, which under different aspects constitutes the basis of serous membrane, the true skin, the bloodvessels, (except perhaps their middle coats), the ligamentous tissues - and in short in almost all parts except the nerves, and the proper muscular substance -

The Horny parts, such as the nails, and the epidermis, are the only parts that are really free from this membrane - they present a totally different structure.

Various opinions have been advanced as to the intimate structure of this membrane; Haller & others state that it is composed of distinct fibres of a regular form and magnitude, caused by the crossing and interlacing of numerous fibres -

But this doctrine has been strongly opposed by Wolf, Meckel and Blumenbach, who maintain, that in the natural state it is nothing more than a layer of glutinous matter destitute of every thing like laminae and cellules, which they assert are caused by the anatomist in his anxiety to display the correctness of his own views of the minute structure of this tissue. The modern views are, that Cellular or Areolar tissue is composed of a network of minute fibres and bands, interwoven in every direction, so as to leave innumerable interstices, which communicate with each other. And according to Profs Todd and Bowman, the two kinds of Fibrous tissue which elsewhere exist separately, the white, and the yellow, - may be detected in Areolar tissue.

If we take a muscle from a recently killed animal, and examine its cut surface we shall find, that innumerable layers of this membrane, are to be seen

passing in between the different bundles of fibres and even between the fibres themselves, which we can readily draw out to a considerable distance with a forceps- If air be blown under it, the cellular membrane is raised up from the muscle & is thrown into a bead like form, this circumstance is taken advantage of by the butchers to give to Veal and lamb, (which abound in cellular tissue) an appearance of plumpness and fatness, which they do not possess.

If we inject water under the membrane, and then freeze it, irregular pieces of ice answering to the shape of the cells can be picked out — Or if we inject, a coagulable substance such as the albumen of an egg, and then boil the membrane, the coagulated albumen, can be obtained, answering to the shape of the cell it occupied.

The cells of this membrane are perfectly continuous one with another. Thus as before stated, both air and water injected into any part of it, find their way, in other parts at great distance. This was performed by the Parisian Impostor, who inflated his child's head to make it look Hydrocephalic.

In disease, the serum of dropsy diffuses itself to the lowest parts, and to those which present least resistance, thus we find that the most dependent parts as the legs and hands are most frequently the seat of anasarca, which may disappear as soon as the patient returns to the recumbent posture. The air of emphysema and that artificially introduced observe the same laws - And the observation applies equally to the blood of ecchymosis —

These arguments for the cellular nature of this

embrane, and in support of the view that the cells ommunicate one with another, have been met, by the pponents of this doctrine, with the statement, that all ese phenomena are quite explicable by the fact that the embrane is nothing more or less than a layer of iscous substance which admits both air & water percolate through its substance, in obedience ith the ordinary laws of gravitation.

When in thin and delicate layers, this membrane transparent and almost colourless, but in situations here it is more abundant and denser it acquires whitish hue.

It possesses great extensibility and retractility s may be seen if we blow under it, so as to istend the cells, when it immediately retracts and jects the air –

If deprived of water and dried, it loses ome of its properties and acquires new ones; in his state it is hygrometrical, and soon resumes ts former appearance. Exposed to heat, it crisps & urns, but leaves very little ashes. It is not easily elted, and for this purpose requires great boiling. It is not decomposed by maceration; but when mac-erated successfully, it forms a viscid substance ike mucus.

It is principally supplied with vessels carrying white lood, though not exclusively so. Haller and Albinus nsidered it impossible to inject it, but in inflammation essels become gorged with red blood, and it is likewise bundantly supplied with nerves –

This membrane is the first structure which is formed the embryo, and it constitutes almost the entire of ny of the lower animals. The Poriferae are almost

[a]ltogether composed of cellular tissue.

"The first trace of an organised structure in the [e]mbryo consists of a very soft and pulpy cellular tissue [w]hich at this period is loaded with fluid, and being [h]omogeneous in its nature, it presents neither fibres, [n]or interstices, although it may be readily permeated by [a]ir or liquids, so as to produce small cells, and may [l]ikewise be drawn out into glutinous filaments. In [p]roportion as the several organs become developed, it [a]cquires greater consistency, and is at the same time [d]iminished in quantity. At the period of birth, it is [s]till, however of a very soft and imperfect state, and [o]nly acquires its proper density by slow degrees; in [o]ld age, being deprived of a large proportion of its fluid, [a]nd perhaps otherwise deteriorated, it loses much of its [e]lastic force; and this circumstance joined to its di=[m]inished bulk, is a principal cause of that loss of [ro]tundity so conspicuous in the bodies of aged persons, [a]nd of the flabbiness of the several organs." *

It also possesses immense powers of self formation when destroyed accidentally, it is immediately re=[p]laced – as is seen in wounds, and morbid growths, [th]e principal portions of which, are formed of this [s]ubstance, more or less modified by the nature of [th]e disease.

It seems also to possess a species of contractil=[it]y or tonicity – as is exemplified by its propelling fluids [c]ontained in its cells –

Uses and Functions of Cellular tissue

1st It determines the form of all parts.

* Granger. Cyc of anatomy –

2. It forms a bond of union between all their parts, and upon its integrity depends the cohesion of the other structures.
3. By its elasticity, it restores the organs to their proper position from which they may have been displaced.
4. It is the seat of the perspiratory secretion -
5. It is the essential organ of absorption. It is it, that lies under the corpus mucosum of the skin, the spongy & villous substances of the mucous membranes. This latter property can be readily proved by introducing a poison into the cellular tissue of an animal.
6. The Cellular tissue which penetrates into the substance of an organ, connects all its parts -
7. When other parts are diseased, the cellular tissue is more or less engaged: thus any obstruction to the circulation through the heart, lungs or liver is followed by the infiltration of the serous portion of the blood, into the cellular tissue constituting general dropsy -

It is subject to various morbid changes, when cut into it inflames, becomes covered with granulations and then cicatrises -

When it is divided and placed in contact with itself the applied surfaces adhere at first by means of a fluid poured out by the divided surfaces when the bleeding and pain have ceased. At a later period this organisable substance becomes a highly vascular tissue.

Inflammation of the cellular membrane is characterised by the following changes or steps -

1st Decided increase of vascularity.
2nd It becomes sensible and painful.
3rd It entirely loses its permeability and fluids cease to make their way through it.
4th Its consistence is augmented & its tenacity diminished.

5th It tears or breaks under pressure, in place of elongating as it previously did.

Pathology of the Cellular Membrane.

Air may insinuate itself into the cellular tissue which constitutes emphysema. Leucophlegmasia, or anasarca consists of an accumulation of serous fluids in the cellular tissue. In ecchymosis the cellular tissue contains blood diffused into the areolae. Foreign bodies produce 3 phenomena, pus is secreted at their surface in the cell tissue; it unites & resumes its softness and permeability behind them, and ulcerates before them. These are 3 of the kinds first admitted by John Hunter, the adhesive, suppurative and ulcerative inflammations. These phenomena together have rec'd the name of eliminatory inflammation.

The cellular tissue sometimes contains worms. The Cysticercus cellulosae, so named on account of its seat in the cellular tissue, and the Filaria medinensis, whose existence cannot be called in doubt are met with in it; and in animals; larvae of the oestrus.

Chemical Properties. It contains a large quantity of water albumen and gelatine.

Microscopic Characters. It presents an inextricable interlacement of tortuous and wavy threads, intersecting one another in every possible direction. They are of two kinds. The first are chiefly in the form of bands of very unequal thickness, and inelastic. Numerous streaks are visible in them, not usually parallel with the border, though taking a general longitudinal direction. These streaks, like the bands themselves, have a wavy character but they are rendered straight by being stretched. The streaks seem more the marks of longitudinal creasing, than a true separation into threads. For it is impossible by any art to tear up the band into filaments of a determinate size, although it manifests

decided tendency to tear lengthwise. The larger of these bands
[are] often as wide as $\frac{1}{500}$ of an inch; they branch, or unite
[wi]th others, here and there. The smaller ones are often too
[m]inute to be visible, except with a good instrument.
[T]hese are the white fibrous element.

The others are long, single, elastic, branched filaments,
[w]ith a dark, decided border, and disposed to curl when
[no]t put on the stretch. These interlace with the others, but
[a]ppear to have no continuity of substance with them.
[T]hey are for the most part about $\frac{1}{8000}$ of an inch in
[th]ickness; but we often see, in the same specimen, others
[o]f much greater density. These form the yellow fib-
[ro]us element (beginn)- *

* Todd's Physiology p. 73 & 74.

3

Adipose Membrane –

W Gill M.D.

27th May 1851

To illustrate

2 drawings page 81. Todd
Fat cells - page 82 and 85
Use Microscope - to show fats &c

Glycerine
Spermaceti
Mutton Tallow
Beef do

extend the Lecture 2½ pages -

Adipose Tissue - so called from its containing the adeps or fat. It may be divided into 2 Kinds - viz the common adipose tissue and the Medullary membrane contained in bones.

This membrane was for a long time confounded with the cellular membrane. Though Morgagni, Malphigi and others pointed out some particulars of dissimilarity, yet its true nature was not properly understood till the researches of Dr William Hunter were made public, and soon after, his views were confirmed by the observations of Wolf, Prochaska, Beclard and others.

I must not however, omit to mention that both Bichat and Meckel adhere to the opinion of Haller that there is no such thing as adipose tissue, and admit, only the areolae of the cellular tissue, as constituent parts of the fat.

It presents different appearances under various circumstances - "under the skin it forms a layer varying in thickness" - rounded masses in the orbit, in the cheeks, in the pelvis, and around the Kidneys. -

In some parts as at the edge of the omentum, these masses are piriform, and in the omentum, the fat is arranged in a delicate network running along the direction of the vessels. It is very abundant about the face as in the cheeks, & parotidean cavities - At the back of the neck, in the chest, between the pectoral muscles. About the heart and around the mammae. In the abdomen around the kidneys, in the pelvis, in the mesentery and omentum.

In the extremities, opposite the angles of flexures and where there is much pressure, as on the buttocks, the soles of the feet, and the palms of the hand -

It assumes a peculiar arrangement according to the situation in which it is examined. Except in cases

[i]n great emaciation we can always find it under the [s]kin, sending in processes to the dermis. We do not find [a]ny under any of the mucous membranes — the serous [a]nd synovial membranes, are "doubled" by this membrane, [p]articularly at their folds — it also exists between the [l]obules of the lobulated glands — It is also to be found, [i]n small quantities, between the fasciculi of the large [n]erves, as the Sciatic — and in the bones, it constitutes [t]he medullary membrane. It also sinks deeply under [s]ome muscles as the gluteus maximus. In some situa= [t]ions, it is never found, as under the skin of the nose, [u]nder the scalp, in the ear, on the point of the chin, at [t]he median line there is very little between the skin and [t]he platysma myoides, nor can we find any at the [i]nsertion of the Deltoid — We find very little along [t]he slender tendons, nor is it to be found between muscles [t]hat perform powerful motions, as for instance, be= [t]ween the Rectus femoris, and triceps, or between the [b]iceps and brachialis anticus.

It is also absent in the substance of the viscera as [i]n the walls of the Stomach, Uterus, liver, Spleen, [g]alpebrae, penis & lungs.

There are some parts of the body, in which it can= [n]ot be found even in Cases of the greatest obesity, whilst [i]n some others, the greatest emaciation, does not Cause [i]t to disappear. The liver is loaded with fat in Phthisis.

In an adult man, of ordinary condition, the fat constitutes [a]bout one twentieth of the entire weight of the body.

It varies in colour, but is mostly of a yellowish [w]hite colour.

It occurs in masses of various sizes from that of [a] pea, to the size of a hazle nut, generally round in form, [b]ut along the median line, they present an oval form,

+ as on sole of the foot and palm of the hand,

The granules of fat are connected one to another, by very delicate laminae of cellular membrane.⊙ In the sole of the foot, where greater elasticity is required, the masses of fat are separated by strong layers of fibrous membrane, by which great elasticity is given to the foot. In order, satisfactorily to examine the membrane between the granules of fat, we should do so, in a body the subject either of emphysema or anasarca.

⊙ 1st to prevent motion
2 to transmit the vessels.

ne extremity being in connexion with the skin, the other with the subjacent aponeurosis.

Microscopic characters. The membrane of the adipose vesicle does not exceed the $\frac{1}{20.000}$ of an inch in thickness, and is quite transparent. It is moistened by watery fluid, for which, as Mr Paget has suggested, it has a greater attraction than for the fat it contains. It is perfectly homogeneous, having an appearance of compound structure, and consequently belongs to the class of simple or elementary membranes. Each vesicle is a perfect organ in itself; is from the $\frac{1}{300}$ to the $\frac{1}{500}$ of an inch in diameter, when fully developed (exactly resembling the vesicles of a lemon or orange); and is supplied on its exterior with capillary blood vessels, having a special disposition.

The fat vesicles are usually deposited in great numbers together, and they then become flattened on their contiguous aspects, × and assume a polyhedral figure more or less regular (figure 1). But if isolated, their form is rounded, as may be seen in eminent beauty in the double series of them which frequently accompanies the minute vessels traversing membranous expansions of the areolar tissue, and other lamellar structures, as the mesentery of small animals. The vessels are thus attended by fat vesicles, for the manifest purpose of protection from the pressure to which they would be exposed in their open course, and they throw around each vesicle a capillary loop. ##

The blood vessels can be easily seen, they enter the chinks between the lobules (figure 2 & 3) and soon distribute themselves through their interior, under the form of a solid capillary network, whose vessels occupy the angles formed by the contiguous sides of the vesicles, and anastomose with one another at the points

may often discern a little aqueous fluid, between the elaine and the cell membrane on the side farthest from the star (fig 5 a.a); a condition by the way which is very favourable for the observation of this membrane itself.

hen these angles meet. This is one of those situations
here the capillary vessels can be most unequivocally
roved to possess distinct membranous parietes.
Malphigi believed that these vessels were surrounded
y a secreting apparatus, and by a canal which
erminated in the granules of fat.
The Absorbents of fat are not well understood,
ut their existence, is proved by the rapid disap-
earance of the fat, in disease or in starvation.
Chemical Properties. It is distinguished into two
solid proximate principles, Stearine and Margarine,
ombined with a fluid one or oil Elaine. To obtain these
principles. 1st Boiling alcohol dissolves both, but on
cooling deposits the stearine in white flakes.
Pressure will separate the elaine. Stearine remains
solid at 167° and Elaine remains fluid at 63° or
65°. Margarine is separated from Stearine by Ether
which dissolves margarine but not stearine.
Together with these, there is another principle called
Glycerine from its sweet taste. The acids of fat are
the Stearic, Margaric, and elaic; and the proximate
rinciples are, respectively, a stearate, a margarate
nd an eleate of Glycerine.

Fat boiled with an Alkali forms soap, and
the glycerine remains dissolved in the fluid.

These two principles often separate within the fat
esicle. The solid part collects to a spot on the inner
urface of the cell membrane, and looks like a
mall star. The Elaine occupies the remainder
f the vesicle, except when the quantity of fat in the
ell is smaller than usual; in which case we #

Hunter distinguishes 4 varieties of Fat, 1. oil. 2 lard 3 Tallow, 4 Spermaceti - Lard melts at 86° tallow at 104° - Spermaceti is fluid at 115° but solid at 112° F.
Oil is elaine with little or no stearine, as the neats foot oil, obtained from the bones of the ox - In lard the Stearine is in abundance, but the elaine slightly predominates. In tallow and spermaceti there is a predominance of Stearine.

Ultimate Analysis of fat. Chevreul.

Hydrogen	11.416
Carbon	79.000
Oxygen	9.584
	100.000.

Distribution.

Fat is found in a great variety of animals - in the articulata, the Mollusca and vertebrata -
It is very fluid, in fishes and the Cetacea. The head of Physeter Macrocephalus contains a fluid oil - in which a concrete fat matter occurs - spermaceti -) soft in the hog (lard), firm in ruminating animals, (suet and tallow) - Hare has no fat.
It accumulates in different situations, in different animals, as on the back in the camel & dromedary - in the tails of certain sheep - between the peritoneum and abdominal muscles of birds - and even in the human race, it varies much in this respect - the Bushman Hottentots, have a large deposit on the hips and nates. The Hottentot Venus was remarkable for this striking feature. In Hybernating animals and in hogs, it abounds at the beginning of winter.
Women in general, have a greater quantity of fat than men -

[t]he foetus is destitute of fat, until the middle of the fourth [m]onth; from thence until birth, the fat accumulates in [d]ifferent parts. It first commences under the skin, & [i]n the cheeks, then in the omentum, and finally, at an [a]dvanced period of utero-gestation, it is found surroun[d]ing the viscera.

When the growth of the body ceases, it is then that [c]orpulence commences. Obesity in children is unusual [b]ut still it does occur. The Fat Boy in Pickwick! [I]n old age the quantity of fat, diminishes, and hence [t]he shrivelled appearance, acquired by the skin, for it is the fat underneath the integuments which disappears, [w]hilst it accumulates (as a disease) around the [h]eart, in the bones, &c.

The sole function of the adipose membrane is to [s]ecrete fat - it is not secreted from particular glands. The Vesicles of the Fat ~~[illegible]~~ are originally furnished with [n]uclei, with a central granule or nucleolus - The nu-[c]leus is situated on the inner surface of the cell mem[b]rane, or if this be thick, in its substance. The nucleus [i]s speedily absorbed and never afterwards appears. Thus it is probable that the original development cell [a]ssumes a permanent form in the adipose vesicle. ([F]igure 4).

Formation of Fat - The Elements of the Fat, are to [b]e found in the blood - Both Elaine & Stearine exist [i]n it, as proved by the researches of Lecanu; about [f]our parts in the 1000 parts of blood. In some cases [t]he fatty matter accumulates in the blood. M. Blainville [f]ound a large quantity of fat in the blood of the last [E]lephant he dissected at the Jardin des Plantes.

The Fatty.
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4th 2 h

The Fatty matters are supplied to the blood, from those constituents of the food, and from those parts of the food which resemble it most closely, viz Starch, gum, sugar, alcohol, beer, all of which are non-nitrogenized. Liebig states that by the separation of a small quantity of oxygen, any one of these substances is readily converted into Fat.

When the body continues of the same size, the balance between the secretion and the absorption of the fat, is kept at its normal standard, but when this equilibrium is disturbed, corpulency or emaciation takes place. Children rapidly emaciate, and as quickly require their original size. Hogs do the same — Certain Birds are said to get fat in wet weather, in less than 24 hours.

Circumstances most favourable to the secretion of fat, are the absolute rest of the animal and intellectual organs as Indolence, rest and idleness, and Castration which causes a large growth of fat — Domestic Animals are, with this view, frequently castrated, when no other reason for this cruel operation can be offered.

The resorption of fat, is caused either by, excessive fatigue, profuse secretions, organic diseases, or great mental anxiety.

Uses of Fat. Purely mechanical —

1st To moderate pressure, as in the soles of the feet and in the Hips. the camels foot & the Bears foot answer —

2nd To fill up cavities —

3rd To render the form of the limbs more rounded & graceful — This explains the greater roundness and plumpness of the limbs of women and children.

4th It protects against cold, and also against Caloric.

he animals of cold climates are covered with a thick layer
f this substance, and the feet of the Camel (which traverses
te burning desert) are supplied with a thick compact
ushion of this substance —

Bichat thought that it served to lubricate the skin by
kind of transudation through the substance of the latter.

5th. The fat is the nutritious store provided by nature for
the support of the economy during disease or starvation.
"A very curious instance of life being supported by the ab=
orption of the fluids of the body occurred some years since
t Dover. A Hog weighing 160 pounds, was buried under
portion of the cliff, which fell on its stye, for the long
pace of one hundred and sixty days. At the end of this
ime, being dug out, it weighed only 40 pounds, and was
xtremely emaciated, clean and white. As there was
either food nor water in the stye when the cliff fell, this
og must have existed during the time mentioned by the
emoval of the adipose and other fluids from their con=
aining structures, into the circulating system". *

This use of fat, is observed in some Insects ~~with~~
hich live upon it before they acquire their perfect state,
nd hybernating animals, become very fat during the
ummer months, and are nourished by their own fat
uring the months, they remain torpid, and when they revive
nd wake from this state, they are found extremely ema=
ciated. This is constantly observed in the case of the
Northern Bear.

After recovery from protracted illness attended
ith loss of appetite, the patient is found to be greatly
maciated — the limbs are shrunken, the skin harsh,
e features prominent and sharp and the eyes are sunk
eep into their sockets —

* Grainger p. 139

Diseases of the Adipose Tissue. Those of most common occurrence are morbidly formed adipose tissue, as in fatty hypertrophy; abnormal adipose tissue, as in the fatty degeneration of many organs, for example, of the muscles and the kidneys; independant fatty tumours, which either consist entirely of fatty tissue, as lipoma, or of a union of that with areolar tissue, forming steatoma. All these formations are characterized by the fat being enclosed in peculiar cells (fat cells) which more or less resemble those of normal adipose tissue*. These fat-globules may occur either free amongst other histologic elements, as for instance, between the hepatic cells in many forms of fatty liver; between the different coats in obliterated vessels; in the substance of encephaloid; and in certain fluids, as in blood, pus, &c; or they are found in the interior of cells as in those of the liver. †

Differences between Adipose Tissue and Cellular tissue -
The adipose tissue differs from the Cellular tissue in the following particulars.

1st The vesicles of A. T. are closed all round, they do not communicate with one another - fluids cannot penetrate from one to another. Heat will not effect any change in them (if not too great) by liquefying the fat and thus inducing it to escape. If an adipose packet be exposed to 104° Fahr: though the fat be quite melted, not a drop will escape - unless the vesicles are cut, when it flows out in abundance. The adipose matter, therefore, though semifluid, does not obey the laws of gravity.

2nd The adipose vesicles do not communicate, like those of cellular membrane - they are each separate and distinct - and are merely applied in apposition.

* Plate 7. fig 1 † Plate 1. fig 9 Vogel's Path Anatomy -

3rd The Anatomical situation of Adipose Tissue is different from that of cellular Membrane.

1st In a considerable layer extending immediately beneath the skin.

2nd In the trunk & extremities round the large vessels.

3rd. ~~Beneath~~ Between the serous and muscular tissues of the heart.

4th Between the peritoneal folds of the omentum and mesentery.

5th Round each Kidney.

6th In certain folds of synovial membrane, outside the articular capsules - as in the glands of Havers.

Fat though chiefly found in animal bodies, may be procured from certain specimens of the vegetable Kingdom - A sort of tallow is obtained from the Vateria Indica, a forrest tree of the Camphor tribe, indigenous in the Indian archipelago - In a species of Croton, the Croton Sebiferum of Linnaeus, indigenous in China - the seeds are covered with a quantity of fat closely resembling tallow. The same is observed in the Stillingia of Michaux - this fat is used by the Chinese to make Candles - The fruits of the Aleurites triloba, a native of the Sandwich Islands, of the same family a Crotons - are the Candle nuts of the inhabitants -

2 - The Medullary Tissue - membranous vascular and vesicular - occupying the interior of bones -

Synonymes. Marrow - Medulla - Meditullium -

It occupies the cavities of long bones - the cellular cavities of short bones - the extremities of long bones - the smaller porosities of bones are also occupied by it; there is none, in the sinuses or air cells of the bones of the skull (as the Ethmoidal or mastoid cells) -

The medulla is shaped in a cylindrical form and is enclosed in a delicate membrane - the medullary membrane - called by some the internal periosteum -

this tissue is extremely delicate, "and can be compared to nothing but a spiders web" — It completely lines the cavities of the long bones, and sends processes ~~with~~ into all the apertures ** in the bones communicating with the large canal in the bone -

It is in every direction, permeated by delicate vessels, supported by extremely fine cellular membrane - in this respect resembling the pia mater - seeming to be produced solely by the cellular membrane of the vessels.

An artery and a vein penetrate into the medullary canal, and then divide into 2 branches, the minute twigs from which, are distributed to the two ends of the bone, and there inosculate with the vessels sent to these parts by arteries in the neighbourhood.

Lymphatics - have not been detected -

The Nerves of the Medulla have been delineated by Wrisberg and Klint -

The Medullary Tissue is composed of

1st An arterial and Venous Network and probably of a network of Lymphatic vessels -

2nd of a nervous plexus -

3rd of the cellular sheath proper to these parts -

The fat of the Medullary Membrane is composed of the same materials as the common fat, only in different proportions, since it is more fluid. It is also more yellow -

Experiment to prove the sensibility of the Medullary membrane - Duverney - introduced a stilet into the medulla, and the animal evinced the perception of pain immediately -

According to Bichat, the medullary membrane is formed before the bone itself, but here it is filled with carti=

-aginous matter, which, as the bone grows, gives place to the Medullary fat -

Beclard has found that the medullary structure contained 7 parts fat, the remainder (1/8th) was composed of vessels (arteries, veins, membrane) water & albumen. this subject only 4 parts fat -

Uses of the Medullary tissue -

1st Internal periosteum -
2nd a Reservoir for fat -
3rd For the vessels to ramify upon -
4th To fill up, what would otherwise be void. -

Haller and Blumenbach, thought it rendered the bones more flexible - but the bones of Children are more flexible than those of the Adult though they contain much less fat - Haller also thought that the medullary tissue was subservient to the reproduction of bone. Objections - Childrens fractures unite more rapidly than those of adults, yet they have not so much medullary membrane. Some bones in adults have no medulla (as clavicle) - Some animals, as birds, have no medullary tissue in any of their bones - The Horns of stags are likewise destitute of it -

Pathology of the Medullary Membrane - When there is an excessive development of the medulla of bones, or of the tissues which occupy its canals and cells, it produces the disease called Osteoporosis. Here there is a dilatation of the Haversian canals and cells. The walls of the enlarging cavities become thinner and thinner, till at length apertures are formed in the interior of the bone, as well as in its outermost lamellae, and the cavities communicate with one another. They are filled with a large quantity of darkish red or reddish brown medulla, which is traversed by dilated vessels and contains here and there loose

form clots of extravasated blood. Osteoporosis may affect the outer compact portion of a bone, or it may affect a bone in its whole thickness. This form of disease is a consequence of excessive developement of the medulla of the bone and of the soft parts which fill its cavities. Sometimes there is inflammation of the medulla & bone together. In Mollities Ossium, the bones become saturated with fat.

Serous Membranes.

L. D. Gibbs MD

1 June 1857

To illustrate

drawing - epithelium of Ser. Mem. Todd 129
do Yellow fib. elem. do 130
do Synov memb wrist Joint - Wilson
large folio Vol of bursae with plates -
use Microscope -

add more on Ser: Mem: proper, say 1 or 2 pages
quote 2 pages or so, from Mr Coulsons paper in
Lancet Vol 1. for 1851.

Serous Membranes

"are soft, broad and thin parts, which line the cavities, envelope the organs, enter into the composition of a great number of the latter and of themselves constitute some. They differ greatly from each other in their texture, composition and action." Beclard -

They are called Serous from the numerous serous vessels in their substance, which are not visible to the naked eye, and which carry a white serous fluid, which appears to be identical, in general and chemical characters with the serum of the blood or with very dilute liquor sanguinis. No red vessels are discovered in them.

Bichat first accurately described them -

The serous membranes are of two principal kinds.

1st Those which line the visceral cavities, e.g. the peritoneum, pericardium, pleurae, arachnoid and tunicae vaginales. To which I have added the peri-choroid which lines the cavity in the eye, between the sclerotic and choroid coats.

2nd The Synovial membranes lining the Joints;
The Sheaths of Tendons and Ligaments; and
The Synovial bursae, or bursae mucosae whether subcutaneous or situated beneath tendons that glide over bones.

To speak of the first kind or the Splanchnic Serous Membranes. They formed closed or shut sacs, compared by Bichat to an inverted or double night cap, and exist wherever the free surfaces of the viscera come into contact with each other or lie in cavities unattached to surrounding parts.

the viscera which are invested by a serous membrane, are as it were, pushed into the shut sac ~~form~~ which it forms, carrying before them a portion of the membrane which it serves ~~as~~ their investment. The two layers of the serous membrane are thus in contact with one another, although not communicating, and are separated by a fine vapoury secretion. They are entered only by the blood vessels which supply them with nutriment.

To the law that serous membranes form shut sacs there is, in the human subject, one exception, viz: the opening of the Fallopian tubes into the abdominal cavity, — a structure which exists in man and all Vertebrata, with the exception of a few fishes.

They always present 2 surfaces, one attached, the other free. And they are usually found in connection with fibrous membrane.

The external surfaces are connected to neighbouring organs, except the arachnoid, it is free in almost all situations. The cellular membrane connecting is called the Subserous cellular membrane.

The Connexion of the Serous Membrane to subjacent organs varies in intimacy in different situations; — the Peritoneum adheres so neatly to the Urinary bladder, to the duodenum and to the pancreas that it may be stripped off these organs; it is closely connected to the other abdominal viscera. It adheres more closely to the articulating surfaces of the bones than in any other situation. This union is so intimate Dr Gordon and even Magendie deny that the parts are covered with synovial membrane.

Jacobs membrane in the eye, is now also classed among the serous membranes.

Bichat thought that the serous membranes by surrounding
and isolating the different organs in connexion with
them, served to limit diseased action - this is not true.

Their Physical properties - Their free surface is smooth and
glistening when examined with the naked eye; but when
examined by a microscope of even low power, it presents a
villious surface. Its colour is somewhat white, but
this is not very perceptible owing to its great transparency.

They are distensible and elastic; thus in the [illegible]
movements of the vertebral column the spinal portion
of the arachnoid yields and recovers itself with great
facility; the pleura being alternately extended and
contracted follows incessantly the motions of the ribs;
and the pericardium is as constantly influenced by
the diastole and systole of the Heart. The peritoneum
is the best example, as these qualities are familiarly
exemplified in pregnancy and in dropsy -

They can also be stretched to a great extent without
rupture. Scarpa fastened a layer of the peritoneum on a
[illegible] and having tightly stretched it, he found that
it supported a weight of 15 lbs without rupturing). #

~~[illegible]~~ 2 properties. (Microscopic) - 1 Synovial and serous
membranes appear to be essentially alike in their minute
structure. On their free surface is a single layer of
epithelium (figure), the particles of which are polyg
onal in shape and of transparent texture. A small
fragment of this pavement, from the peritoneum of the
[illegible], is here represented. This was discovered by Henle.
Todd & Bowman have found this epithelium to rest imme
diately on a continuous transparent basement membrane.

excessive tenuity, apparently identical with that which supports epithelium of mucous membranes. Beneath this a lamina of areolar tissue, which constitutes the chief thickness of the membrane, and confers on it, its strength and elasticity. This areolar tissue is traversed by a network of capillary vessels, the meshes of which are large and of rather unequal size, and by lymphatics and nervous filaments in varying number. It is of close texture, and continuous with that laxer variety by which the membrane is attached to the parts it lines.

The most favourable position for examining the areolar tissue of serous membrane, is the transparent part of the mesentery, or of any of the duplicatures of the peritoneum in small animals.

Here we observe the yellow fibrous element assuming very beautiful arrangement (figure). Its filaments interlace and inosculate chiefly in a plane beneath the basement membrane, in such a manner as to confer equal elasticity in every direction. The intermediate space is occupied by the white fibrous element disposed in wavy bands, variously intersecting and which become straight out, when the elastic threads are stretched.

Serous membranes 1 have very few nerves. 2 They have no vessels carrying red blood. 3 They have no distinct glands. 4 They have exhalents and absorbents, as proved by the rapidity with which dropsies are absorbed.
5 The healthy secretion is analogous to the serum of the blood, of a pale straw colour, viscid, alkaline, and contains albumen. 6. They are of great importance in the animal economy as forming envelopes for the viscera, and usually those considered vital viscera.

Uses of their Secretion - 1 to afford a separation between

~~Sacs Membrane in the ΨΨ, is now also classed among the serous membranes.~~

folds of the opposed membrane 2 to facilitate the motions of the organs different upon one another. 3 Beclard thinks that the nutritive matter, thus alternately deposited and taken up, undergoes a more perfect assimilation before being employed for the nutrition of the organs.

In the embryo the abdominal viscera appear to be only covered with a very thin coat of fluid, or viscous varnish. In the foetus they are very thin and generally less adherent, owing to the softness of the cellular membrane connecting them to the organs.

Vital Properties. These membranes exhibit in their inflamed state, a remarkable tendency to throw out lymph on their exterior, so as to cause adhesion of their opposed surfaces. Hence a frequent result of inflammation of a serous membrane is the obliteration to a greater or less extent of its cavity. Synovial membranes are not so prone to the adhesive inflammation as the serous are.

The lymph effused in the larger membranes becomes gradually converted into areolar tissue and vessels.

In inflammation the vessels become red which exist in the subserous cellular tissue. It decreases the membrane, produces thickening and loss of transparency, effusion of serum and lymph and adhesion -

Synovial Membranes lining the Joints.

Under the name of Articular Synovial Capsules, are desig[nated] the serous membranes of the diarthrodial articulations. [M]ost of them belong to bones, although some belong to Carti[la]ges; as is the case with respect to the larynx. Monro first [re]marked their resemblance to the other synov & ser: mem. Bichat gave a general description of them.

Beclard has divided them into the following Varieties -

1st A Simple Ampulla. Rounded and simple bags, like [th]e vesicular membranes of the tendons. Seen in the artic[u]lations of the phalanges with each other, and with the [m]etacarpus and metatarsus.

2nd An Ampulla raised by adipose projections. In some [ar]ticulations, the cavity of the membrane seems traversed [by] a ligament or tendon; around which the membrane [is] reflected upon itself, forming a sheath which is [co]ntinuous at its 2 extremities with the common envel[o]pe which the synovial membrane furnishes the joint. [T]his synovial membrane is then vaginiform. [M]et [wi]th in the hip and shoulder joints &c.

3rd An ampulla raised by adipose projections, as in [th]e last variety; but joined to the presence of sheaths. [G]reater complication is observed here. In the knee for [ex]ample, there occur a common envelope, sheaths [fo]r the tendon of the popliteus muscle and the adipose [m]embrane; and moreover, folds pass round the [se]mi-lunar & crucial ligaments, which raise the [m]embrane and project into the joint.

ths Besides the presence of sheaths, folds formed by parts [w]hich sink into the joint, & are invested by the membrane.

The outer surface of the synovial membranes [ar]e more or less intimately connected with the neigh=[bo]uring parts. Their connexion with the cartilages [co]vering the bones ~~are~~ is most intimate. They are equally [in]timately connected with the articular membranes [an]d the exterior of the joint.

Their inner surface, is smooth, polished, in con[tac]t with itself, lubricated with synovia, and fur=[n]ished with villosities and fringed prolongations.

They are soft, white, extensile and retractile, as [sh]own after removing a dropsical effusion from them.

[The] Haversian glands. Formerly it was supposed that [th]ey secreted the synovia. Their size depends on the [q]uantity of fat they contain, of which they are almost [en]tirely composed. Where these bodies exist at the exte=[rio]r, the Syn: Memb: is thrown into fringes in the [in]terior. They contain cellular tissue, fat & blood [ves]sels. The rest of the synovial membrane receives [on]ly serous vessels. Lymphatics can be seen only [in] some of them.

It is probable that the formation of synovial [f]luid is a process of genuine and elaborated secretion [by] means of the epithelial cells on the surface [of] the membrane, and especially of the synovial [fr]inges; for, in its peculiar density, viscidity and [ab]undance of albumen, synovia differs alike from [the] serum of the blood, and from the fluid of any of [the] serous cavities.

[...]m. prop of Synovia. Lassaigne and Boissel, who have [...]lished an analysis of human synovia, state that it does [no]t coagulate spontaneously; that it is an alkaline [fl]uid containing albumen and salts, such as are found [in] the serum of the blood: and M. L'Heritier has lately [an]alised 2 specimens of this fluid, and completely confirmed [the] statement of those chemists.

It is plain from the description just given, that syno[vial m]embranes contribute to the locomotive function by lu[br]icating the articular surfaces, so that they may glide [s]moothly on one another with the least possible friction, [an]d also by facilitating the play of some tendons over [pro]minent surfaces and of others within sheaths.

[Pa]thological Changes in Synovial Membranes of Joints

[In]flamm^n produces the same alterations of tissue and function [in] these membranes as in the serous membranes in [g]eneral. They become a little thickened, acquire a red [co]lour over a greater or less extent, assume a covering [of] albuminous grains and sometimes contract adhesions. Inf^n may terminate in effusions of pure synovia, milky [se]rum, serum with albuminous flakes, or even true pus. [W]hite swellings, including various alterations as Inf., dropsy [dis]eases of cartilages, &c. It is a state in which these [m]embranes are converted into a fungous substance [fr]om which vegetations sprout up until they reach the [s]kin and even protrude externally. Foreign bodies, most [fre]quently in the knee, they form externally to the [sy]novial membrane and appear to be the result of a [pa]rticular alteration of the nutrition.

Synovial Membranes of the Tendons -

These also form shut sacs, they are divided into two kinds - the Vesicular and the Vaginal -
The first are attached on the one hand to the tendon and on the other to the part on which the tendon glides -
The Vaginal surround the tendon, and line the canal in which they are contained; these two portions joining each other at the extremities, so as to be separated by an interval which constitutes the cavity of the membrane.
In situations where several tendons pass through together, the synovial membrane dips down between them, separating one from another - as at the annular ligament of the wrist - show drawing -

The loose cellular membrane found under the latissimus dorsi, the Rectus femoris anticus, the muscles of the calf constitute in some measure the rudiments of the membrane of which we have been treating. In general these membranes are in connexion with bones or fibrous rings.
" Villosities are found in them, which pour out the synovia." They are whitish, semitransparent, thin, soft; and the Vaginiform are supplied with tendinous sheaths at the exterior.

In texture they resemble the other serous membranes. The Fluid they contain is viscous, more abundant than in the subcutaneous mucous bursae, of a yellowish colour, sometimes reddish - It contains albumen and mucus.

Ganglion is a ~~disease~~ an excessive secretion of synovia, occurring on the synovial sheaths of tendons, with consequent tumefaction and the formation of a bursa mucosum. A recently formed ganglion is a fluctuating tumour, of an indolent nature, transparent enough to permit the light of a candle to be seen through it. It contains a clear synovia; but the various of these bursae which may be formed by friction — such as the bursa which forms the swelling of bunion, do not contain synovia, but a viscid, semifluid substance, like the crystalline lens.

Paronychia is an infl^n of bursae under tendons.

Subcutaneous Synovial Bursae.

The anatomy of these organs was first accurately described by Beclard, though pathologists (as Good, Camper and Brasdin) had directed attention previously to these diseases.

The nearest approach to synovial membranes is to be found in the loose and extensive cellular tissue which exists between parts subject to much motion. Instances of this, are to be found between the skin and the fibula, between it and the olecranon, and between it and the trochanter & acromion. Also in front of the Thyroid Cartilage and sometimes behind the angle of the jaw. It also exists between the skin and the metacarpal and tarsal bones, in which situations, it becomes continuous with the neighbouring tendons. They exist over the

-tella, and in many places over which muscles glide. Enlarged bursae have sometimes been mistaken for aneurism and for other diseases. A man was admitted some years ago into M.G.H with inflamn of a bursa over the trochanter major, which was supposed to be morbus Coxae. The one over the patella is interlocular.

The Best way to demonstrate them, is to distend them with air. They are shut sacs, and are found sometimes to contain roundish multilocular cavities divided by numerous septa –

Their walls are thin and not very strong – They resemble serous membranes in structure, and are possessed of very few vessels, they are lubricated with an unctuous oily secretion, which can hardly be obtained in sufficient quantity to be examined. When inflamed these bursae are often distended wh fluid. The use of these membranes, and of the fluid which they secrete, is to facilitate the motions of the tendons connected with them – They are developed at a very early period – At Birth they are very manifest, and being distended with their secretion can be readily exhibited –

Wherever they exist, their development progresses in proportion with the increase of motion, to which the part is subjected — this is familiarly exemplified in the case of those who carry heavy burdens on their shoulders, or in those who kneel for a length of time on hard substances, as devotees, housemaids, Chairwomen, &c –

[w]herever much friction is used on a part, bursa mucosa [be]come developed, this is seen in cases of club foot, [in] which there will always be found a large bursa under[ne]ath that portion of skin which comes in contact with [th]e ground. It also occurs in the Humps of Hunch-[ba]cks - It is also observed, underneath those masses of [ha]rdened cuticle, called Bunnions, which result from [th]e pressure of tight boots or shoes. After amputation [a] bursa soon forms on the surface of the stump. [Chronic]us Dropsy of these bursae is not unusual - it [co]mmonly occurs in those who either from devotion, [or] from the nature of their trades are obliged to kneel [fo]r great lengths of time.

5

Mucous Membranes.

C. Spitt M.D.

June 3rd. 1851

To illustrate

Second stom of sheep to show depressions
Tan mucous memb of stom &c -
drawings of in Kirkes and Paget
some others besides.
Section of head and neck from Maclise -

extend lecture 4 or 5 pages -

Mucous Membranes. Bichat was the first
to gave a full and accurate description of these membranes.
This membrane and the skin, form the tegumentary
membranes, and this receives the name of internal teg-
umentary membrane or mucous membrane, from its
lining the internal parts of the body and some
of the organs.

The mucous membranes have been divided into three
principal classes: —

1 The Gastro-Pulmonary mucous membrane
2 The Genito-Urinary — do —
3 The mucous mem lining lactiferous tubes in women.

Describe and trace each of these, stating that the first is
subdivided into a Digestive & Respiratory Tract.

See Kirkes and Paget page ~~300~~ — 301

The mucous membrane lines all those passages which
I have just described, by which internal parts commun-
icate with the exterior and by which either matters are
eliminated from the body or foreign substances taken
into it. They are soft and velvety, and extremely vascu-
lar. Their basis or proper texture, seems to belong to
the albuminous structures. Their external surfaces
are attached to various others tissues; in the tongue
for example, to muscle; on cartilaginous parts, to
perichondrium; in the cells of the ethmoid bone,
in the frontal and sphenoid sinuses, as well as in the
tympanum, to periosteum; in the intestinal canal
it is connected with a firm submucous membrane,

ich on its exterior gives attachment to the fibres of the muscular at. The *internal* or unattached surfaces, are free, and at every part invested with one or more layers of ithelial cells, which are separated from the vascular tissue by the layer of basement membrane. This surface also called *villous*, i.e. it presents small elevations, resembling the *pile* of velvet; it presents also alvulae, *folds* and *rugae*, formed by all the coats the membrane being doubled back upon themselves.

In the *oesophagus* the mucous membrane is thick, very osely connected with the muscular coat, and disposed longitudinal plicae. In the stomach the mucous membrane is thin and vascular at the great extremity, and comes thicker and lighter in colour towards the pyloric extremity. It is formed into plaits or *rugae*, hich are disposed for the most part in a longitudinal irection. The rugae are most numerous towards the lesser end of the stomach; while around the cardiac orifice they assume a radiated arrangement.

At the pylorus the mucous membrane forms a circular or spiral fold which constitutes a part of the apparatus of the *pyloric valve*. In the lower half of the duodenum the whole length of the jejunum, and the upper part of the ileum, it forms valvular folds called *valvulae conniventes* which are several lines in breadth in the lower part of the duodenum and upper portion of the jejunum, and diminish gradually in size towards each extremity. These *folds* do not entirely surround the cylinder of the intestine, but extend for about one-half or three-fourths of its circumference. They contain only the mucous membrane and submucous

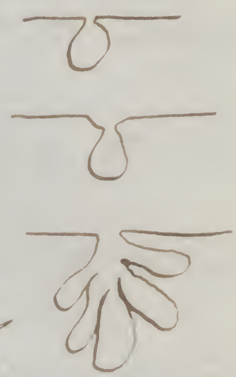
issue; they are constant and never obliterated. In the lower half of the ileum the mucous lining is without folds; hence the thinness of the coats of this intestine as compared with the jejunum and duodenum. At the termination of the ileum in the caecum, the mucous membrane forms 2 folds, which are strengthened by the muscular coat, and project into the caecum. These are the ilio-caecal valve (Valvula Bauhini. In the caecum and colon the mucous membrane is raised into cres=centic folds, which correspond with the sharp edges of the sacculi; and in the rectum, it forms three valvular folds. Besides these folds the membrane in the empty state of the intestine is thrown into longitu=dinal plaits, somewhat similar to those of the oesopha=gus; these have been named the columns of the rectum. The mucous membrane of the rectum is connected to the muscular coat by a very loose areolar tissue as in the oesophagus.

The Rugae in the stomach are not permanent, they are merely accidental or momentary replications, from which they are immediately removed when the membrane becomes dilated. The mucous membrane is every where in excess over the muscular tissue.

The mucous membranes are marked on their free surfaces with depressions and with papillae and Villi. The former are best seen in the second stomach of the ruminants -

Mucous Follicles and Crypts, are generally distributed throughout the membrane, they are of various sizes, but generally very small. A mucous crypt or follicle is the first formation of a gland. The sebaceous follicles

the face are the same as crypts in mucous membrane.
Some are simple and small, they do not in general, open
directly upon the surface; but into the bottom of small
depressions or pits, which may be seen to cover the membrane.
These enter into an opening of which there are many branches;
these end in a common and dilated orifice called a
Lacuna - examples - the lacuna of the tongue,
of the urethra and of the Rectum. Others
are complicated with extensive reduplications
of the membrane and greatly resemble glands,
for instance the tonsils, the prostate
gland and Cowper's gland -



The use of the papillae and of the depressions
is to increase the surface of the membrane,
and wherever one of them is very abundant, the
other is less so.

The *villi* are even more minute than the papillae;
they abound principally at the pylorus, in the small
intestines, and especially at the commencement of that
intestine. Each villus is supplied with an artery, a
vein, a nerve and an absorbent. The veins assume
a somewhat erectile appearance. The villi carry on
absorption. They are absent in some parts of the
mucous membrane, in health, as the Trachea, Larynx
bladder, &c -

The cellular tissue which forms the Corium of the
mucous membrane is more generally *areolar* than in
any other situation. In this membrane the bloodvessels
and lymphatics are abundant. The nerves of the mucous
membranes come from the great sympathetic, and

m the Pneumo-gastric.

Colour from white & red – soft and spongy – Thickness varies and its tenacity is not great.

Mucous membranes, possess some tonicity, not much sensibility, even when inflamed, familiar examples are seen in ulcers in the tonsils and cheeks and on the inner surface of the lips. When lost or destroyed mucous membrane is reproduced with the greatest facility.

Organic Functions. 1 Absorption principally by the villi though not entirely –
2 Secretion partly from the surface & partly from the follicles.
3 Tonic Motions
4 Sensation. These are exemplified in the case of Hunger & Thirst.

Minute Structure of Mucous Membrane. This membrane is analogous to the cutaneous covering of the exterior of the body, and resembles that tissue very closely in its structure. It is said to be composed of 3 layers, an epithelium, proper mucous, and a fibrous layer.

The Epithelium is the epidermis of the mucous membrane. It bears some analogy in its structure and use, to the cuticle or epidermis on the external integument, but presents considerable variety in different situations. It is continuous with the epidermis of the skin at the margin of the lips, and terminates by an irregular border at the cardiac orifice of the stomach. At the opposite extremity of the canal it terminates by a scalloped border just within the verge of the anus.

The epithelia present themselves under three different forms; the characters of each of which are different enough in well marked examples, but when, as frequently happens,

continuous mucous surface possesses at different
nts two or more different epithelia, there is a very
adual transition from one to the other.

e first and most common variety as described by Henle
the tesselated or pavement epithelium, which is com=
sed of flat, oval, roundish, or polygonal nucleated
lls, of various size, arranged in one, or in many
perposed layers. (Figure). This form of epi-
elium is spread over the mouth, pharynx, and oesophagus,
e conjunctiva covering the eye, the vagina, and
trance of the female urethra: a similar epithelium
nes most of the serous and synovial membranes,
so the blood- and lymph-vessels; the outer covering
the skin or epidermis, is constructed on the same
an. Many gland ducts, also, are lined with similar
ithelium cells, and the cells in the finest part of
e ducts, and in their extremities and most actively
ecreting parts, have a similar structure.

he second variety is the cylindrical, or conical epithe-
ium, which extends from the cardiac orifice of the
omach along the whole of the digestive canal to the
nus, and lines the various principal gland-ducts
hich open upon the mucous surface of the tract.
It is also found in the greater part of the male genito-
rinary apparatus and the gland ducts connected with
t; and lines the urinary passages of the female from
e orifice of the urethra to the beginning of the urinary
ubules of the kidneys. It is composed of closely-set
ells of a conical, pyramidal, or cylindrical form,
hose apices are attached to the mucous membranes,
to flat epithelial cells lying upon it, and whose
ses, which are usually terminated by a truncated plane,
re free. Each such cell encloses, at nearly mid-distance

[twe]en its base and apex, a flat nucleus with nucleoli-
[. . .] figure).

In the third variety of epithelium, cells, similar in other
[res]pects to the above, are provided at their free extremities
[w]ith several fine pellucid pliant processes or cilia,
[wh]ich are constantly in rapid vibratory motion, and
[th]e nature of which will be considered hereafter when
[we] come to speak of Motion. This form of epithelium
[l]ines the whole respiratory tract of mucous membrane &
[it]s prolongations. It occurs also in the female gen-
[er]ative apparatus, commencing about the neck of the
[u]terus, and extending to the Fallopian tubes, and, for
[a] short distance, along the peritoneal surface of the
[la]tter. A tesselated epithelium with scales partly
[cov]ered with cilia, lines the interior of the cerebral
[ve]ntricles.

These various kinds of epithelium serve one general
[pu]rpose, namely, that of protecting, and at the same time,
[re]ndering smooth, the surfaces on which they are placed.
[E]ach cell and each scale possesses a central nucleus,
[an]d within the nucleus are one or more nucleus-corpus-
[cl]es. According to Mr Nasmyth, the deepest lamina of
[th]e epithelium appears to consist of nuclei (cytoblasts)
[on]ly; in the next the investing vesicle or cell is developed;
[th]e cells by degrees enlarge and become flattened, and
[in] the superficial laminae are converted into thin scales.
[T]he nuclei, cells, and the scales, are connected together by a
[g]lutinous fluid of the consistence of jelly, which contains
[a]n abundance of minute opaque granules. The scales
[of] the superficial layer overlap each other by their
[m]argins. During the natural functions of the
[m]ucous membranes the superficial scales exfoliate

-stinuelly and give place to the deeper layers.

[The] second is the Proper mucus or Papillary layer, and named [thu]s by some the basement membrane — it is analagous [to] the papillary layer of the skin, and like it, is the [se]creting structure by which the epithelium is produced. [Its] surface presents different appearances in different [si]tuations; in the stomach it forms polygonal cells [or] alveoli, into the floor of which the gastric follicles [op]en. In the small intestine it presents numerous [m]inute, projecting papillae, called Villi. The villi [are] of 2 kinds, cylindrical and laminated, and so [ab]undant, as to give to the entire surface a beautiful [vel]vety appearance. In the large intestine the surface [is] composed of a fine network of minute polygonal [cel]ls, more numerous than those of the stomach, [an]d resembling them in receiving the secretion from [nu]merous perpendicular follicles into their floors.

The third layer is the fibrous lamina (submucous, nervous) [w]hich gives it support, strength and form, and so far is [a]nalagous to the corium of the skin, but seldom [eq]uals it in density; it is also more loosely connec-[te]d to the proper mucous layer than the corium is [to] the papillary layer of the skin. It is chiefly com-[po]sed of areolar tissue, in which the white and [ye]llow fibrous elements can be detected; these con-[ne]ct it to the submucous tissue from which indeed [it] cannot be separated as a distinct lamina; it [co]ntains the capillary bloodvessels, nerves, and [ab]sorbents.

[C]hemical Compos.n of Mucus. Mucus is a white, viscous [tra]nsparent, inodorous and insipid fluid — it does [no]t coagulate like albumen — it is insoluble in

[a]lcohol. It contains 9/10 of water. The best test for mucus [i]s acetic acid, which throws down a precipitate, which [i]s formed from the coagulation of the particles into a thin semi-opaque corrugated membrane, presenting [a]n appearance, which once seen can never be mistaken.

Mucus contains no albumen in a state allowing of [co]agulation by heat or nitric acid; hence mucous [u]rine can never be albuminous like pus unless the [al]bumen be derived from some other source.

Agitated with ether, mucus gives up but mere traces of fat; and in this respect also differs from pus.

Mucus according to Berzelius, contains

Water	933.9
Mucous matter	53.3
Hydrochlorate of Potash & Soda	5.6
Lactate of Soda & Animal matter	3.0
Soda	9
Phos Soda, Albumen & An matter	3.3
	1000.0

[O]r according to Scherer, pure mucus, cleared of epithelium [a]nd subtracting 4.1 per cent of saline matter, contains

Carbon	52.17
Hydrogen	7.01
Nitrogen	12.64
Oxygen	28.18
	100.00

The Functions of the Mucous Membranes sympathise with the general state of the system, and the system sympathises with the mucous membrane. Skin diseases attack the mucous membrane.

The Salivary glands are composed of mucous membrane packed together, and the structure of all the glands is nearly similar. The mucous membrane

of the digestive apparatus is thicker in the Human race, than in the Carnivora, but not so thick as in the Herbivora. Whilst the peritoneal coat of the intestines is thinner in the herbivora, and thicker in the Carnivora than in man.

Mr Quekett * has found the submucous or fibrous layer, firmer, stronger and more elastic in reptiles, more distinct in Carnivorous than in Herbivorous animals or in man. The following is the comparative table of the relative thickness of this layer.

1 Alligator	7 Peccary	13 Chimpanzee
2 Turtle	8 Seal	14 Monkey
3 Leopard	9 Dog	15 Bear
4 Cheetah	10 Cat	16 Ox
5 Horse	11 Man	17 Rat
6 Pig	12 Porpoise	18 Rabbit

Uses of the Mucous Membranes - 1 As an Emunctory - 2. performing the same function to foreign bodies as the skin does. 3 Facilitating the passage of foreign bodies, by means of the mucus they secrete - an example of this is seen in the Boa Constrictor.

Pathology of mucous membranes. I shall speak of when I come to Pathology proper.

We have now seen, that the essential character of the mucous membranes, as regards their arrangement, is altogether different from that of the serous and synovial membranes. For whilst the latter form shut sacs, the contents of which are destined to undergo little change, the former constitute the walls of tubes or cavities, in which constant change is taking place, and which have free outward com=

* Lancet March 1857. Guthrie's lecture -

munications. Thus in the gastro-intestinal mucous membrane, we have an inlet for the reception of the food and a cavity for its solution, the walls of which are endowed in a remarkable degree with absorbing power; whilst they are also furnished with numerous glandulae, which pour the solvent fluid into the cavity. On the other hand, it has an outlet, through which the indigestible residuum is cast forth, together with the excretions from the various glands that pour their products into the alimentary tube. In the bronchio-pulmonary apparatus, the same outlet serves for the introduction and for the expulsion of the air; and here, too, is continual change. In other cases, there is but a single outlet; and the change is of a simpler character, consisting merely in the expulsion of the matters eliminated from the blood by the agency of the glands. Now it is, as we shall see by and bye, in the digestion and absorption of the food, on the one hand, and in the rejection of effete matters on the other, that the commencement & termination of the nutrient processes consist; and these operations are performed by the mucous Membranes, including in that general term the Skin, which is an important organ of ~~secreto~~ excretion.

Skin &c, Hair, Nails.

R D Sibbald MD

6th June 1857

To illustrate

To tan Human skin - Birds skin -
Fig 77 of Todd
78 ——
79 ——
80 ——
81 ——
Fenwicks Carpenter fig 92. p640

add a page or so in any part incomplete
with the plates -

The Skin and the Mucous Membranes con-
stitute the Tegumentary Membranes. They are but one
and the same membrane, though from the circumstance
of part of it being external (the skin) and the other
internal (the mucous membrane) they appear to be dis=
tinct and separate organs.

The mucous membrane if exposed for any length
of time gets a thick coating of skin, as in prolapsus
ani; and if the skin becomes in contact with
any fluids of the body, or of its secretions, it takes on
the character of a mucous membrane & secretes mucous.

The Tegumentary membranes are necessarily of
great extent, for internally they penetrate into the recesses
of the minutest gland or follicle.

It is in every situation in contact with foreign ob=
jects, that is with objects which do not constitute
part of the animal economy.

It has been, not inaptly, compared to a muff,
whose two surfaces are separated by the contained
parts, one from another.

For the sake of convenience, we shall divide these
into two classes - viz the skin, and the mucous
membrane, the latter I have already considered
in a previous lecture.

The Skin is divided into two layers 1st the dermis
and 2nd the epidermis. The dermis is composed
of areolo-fibrous (i.e. cellular fibrous) tissue, together
with bloodvessels, lymphatic vessels and nerves.

The Dermis, is divided into the superficial or papillary layer, and the deep stratum or Corium - the latter abounds in the areolo-fibrous tissue, whose strata are consequently dense, white and coarse. Whilst the papillary layer is fine in texture, reddish in colour, soft, raised into minute papillae and endowed with an abundant supply of vessels -

The Epidermis or Cuticle - is a mere product of the Dermis. It serves as a coating, for the protection of the dermis - the external layer is hard, dry and horny - whilst the internal one, which lies on the delicate papillary layer of the dermis is soft and cellular -

This membrane is consequently divided into the Cuticle and the rete mucosum of Malpighii -

The skin is likewise composed of 1 Sudoriparous & 2 Sebaceous glands, and the appendages of the Epidermis the hair and nails

The Dermis differs in thickness in different situations of the body - thus it is very thick on the soles of the feet, palms of the hands; thin on the penis, scrotum, eyelids and abdomen. It is also much looser in some parts of the body than in others, as over the head, patella and some muscles. Whilst again it is bound down in other places to muscles, as on the hand and foot by red fibrous bands. It is corrugated in scrotum and breast. Ichthyosis is a disease of the dermis -

The areolo-fibrous tissue of the dermis, is composed of fibres presenting the same wavy appearance as the fibres of the common areolar tissue, and of fibres

of elastic substance - presenting the characteristic curved ends and branching distribution -

The yellow elastic fibres are solitary in their arrangement - abundant in the superficial layers of the Corium, rare and scanty in the deeper strata - In the intervals between these fibres, the vessels take their course to the papilla - (Figure 77 Todd.)

Until lately, the Contractile fibrous tissue, could only be detected in the nipple and in the dartos of the scrotum but it is proved to be universally diffused over the body! It is in consequence of this extensive diffusion of the membrane; that the phenomenon of Cutis Anserina is explained -

And the Dartos which before was considered as one of the two organs possessing this contractile membrane, is now proved by Mr Bowman, to possess organic muscular fibres, which are "at once known by its being loaded with Corpuscules or persistent cell - nuclei" -

The papillary layer of the dermis is raised in small Conical shaped bodies - those of the body are generally small of the same size, but those in the soles of the feet, and in the palms of the hands, are much longer and do not present a uniform size - In the latter situation they are arranged in tens and twentys, forming small elevated clumps; - these clumps are then arranged in parallel rows, and this accounts for the parallel lines observed in the palms of the hand and on the soles of the Feet - (Figs. 78 & 79 & 81 Todd

The papillae constituting these clumps and rows are mostly of the same size, but here and there,

may be found one papilla considerably longer than the others. The largest papillae are those which secrete the nails - Each papilla is supplied with a complicated network of bloodvessels and nerves. The arteries, of the dermis which enter its structure through the areolae of the under surface of the corium, divide into numerous intermediate vessels, which form a rich capillary plexus in the superficial strata of the skin and in its papillary layer. In the papillae of some parts of the dermis, as in the longitudinal plications beneath the nail, the capillary vessels form single loops, but in other papillae they are convoluted to a greater or less degree in proportion to the size and importance of the papillae. (Figures 7.8 & Pl. 03 [illegible])

No lymphatics have as yet been discovered in the papillae. But they probably form a plexus in the superficial strata of the dermis, the meshes of which are interwoven with those of the capillary and nervous plexus.

The Nerves of the dermis, divide into minute fasciculi and these quickly separate into primitive fibres, which form loops in the papillae. In the less sensitive parts of the skin the loops are simple, and more or less acute in their bend, in conformity with the figure of the papilla. In the sensitive parts, however, and especially in the tactile papillae of the pulps of the fingers, the loop is convoluted to a greater or less extent, and acts as a multiplier of sensation. Figures).

The Epidermis, cuticle or Scarfskin - is of use to protect the delicate dermis or true skin against the operation both of chemical and physical agents. It is this structure, which is removed, when we

[a]pply a blister and the raw tender structure underneath [i]s true skin -

The outer layer of the epidermis, is hard & horny, [b]ut its under surface is soft and cellular. The [o]uter layer is subject to constant wear and tear, [a]nd is exposed to powerful agents both of a [p]hysical and a chemical nature. It is also [l]aminated, and the laminae diminish in density [a]s we proceed from the outer to the inner layer - [t]his is explained by the mode of growth:—

It is formed by the vascular ~~layer~~ surface of the cutis, and the [p]rocess is supposed to occur in the following manner: [F]rom the capillaries of the cutis, fluid lymph, or blastema, [c]onstantly exudes, in this are numerous cytoblasts, [o]r cell germs; these gradually enlarge into cells, which lie [c]losely pressed together, and cover every portion of the [c]apillary surface of the cutis; as soon as the first layer [i]s completed a new layer is formed beneath it in the same [m]anner, and the layer first separated from the true [s]kin, changes its form and consistence, becomes hard [a]nd flat, then by evaporation dry and firm, and after [s]ome time desquamates; this is succeeded by fresh [o]nes from below or within, and thus the processes of [w]aste and supply constantly keep pace with one [a]nother. (Harrison p 590). *

The Epidermis is thrown into folds at the angles of flex=[i]on and in other situations, where the dermis is sub=[j]ect to much movement -

The series of strata of nucleolo-nucleated cells, which [e]xhibit a process of flattening, composing the epidermis, [e]nables us to split it into laminae, the deepest of [w]hich, composed of the soft and newly formed cyto-blasts

* ~~as~~ also Wilsons Anatomy -

and cells, constitutes the rete mucosum -

The colour of the skin depends on the presence of granules of pigment, which are disseminated in the interstices of the cyto-blasts and cells of the rete mucosum, or developed in the same situation into proper pigment cells. In the superficial layers of the epidermis, as evaporation pro=ceeds, the colour of the pigment is gradually lost.

Analysis of the Pigmentum Nigrum by Scherer.

Carbon	58.273
Hydrogen	5.973
Nitrogen	13.768
Oxygen	21.986
	100.000

Similarity between the skin and mucous membranes - this has lately been extended even farther, by the discovery of Mr Bowman of the basement membrane under all the mucous membranes - on which the epi=thelial scales are lodged - the same structure, he con=siders to exist under the Epidermis - and Wilson and others fully concur with him -

Mr Bowman has detected the basement membrane lining the tubuli of the sudariparous and sebaceous glands - Mr Bowman remarks that it is the basement membrane which gives firmness and form to the minute tubuli of secreting glands -

The Sudariparous glands are situated deeply in the skin, namely the subcutaneous areolar tissue, where they are surroun=ded by adipose cells. They are small, oblong bodies, compo=sed of one or more convoluted tubuli, or of a congeries of globular sacs, which open into a common efferent duct. The latter ascends from the gland through the dermis and epidermis, and terminates on the surface by a

funnel shaped and oblique aperture or pore. The efferent ducts and the component sacs and tubuli of the sudoriparous gland are lined by an inflection of the epidermis. This inflection is thick and infundibuliform in the upper stratum of the dermis, but soon becomes uniform and soft. (Figures Todd & Bowman)

Mr Bowman describes a form of cell which he terms the spheroidal particle; as occurring in the sudoriparous ducts. They are round, rather polyhedral, being flattened by the contact ~~of~~ with contiguous surfaces.

Sebaceous glands. These are sacculated glandular organic bodies imbedded in the substance of the dermis. They present different varieties of complexity, from a mere depression, in the dermis, to the greatest complexity of organisation, being in many places much lobulated and sacculated. (Figure 92 of Todd.

The ducts from these open in many situations on the dermis; and although sometimes isolated, they generally speaking terminate in the hair follicle.

They are raciform and lobulated in their structure, they communicate by short pedunculated tubuli into a common excretory duct, and the latter, after a short course, terminates in the hair follicle.

On the Scalp there are two of these glands for each hair follicle. On the nose, they sometimes attain a great size, and there they are distinctly lobulated and constantly associated with hair follicles.

In the Meatus Auditorius the sebaceous glands are also large and lobulated and secrete wax, but the Meibomian glands are the largest of all. They consist of lobulated glands, which lobules send ducts from all sides & empty themselves into the

main duct leading from each gland—

When the skin is thin, the ducts from the sebaceous glands assume a straight form, but in the sole of the foot and palm of the hand, the ducts assume a spiral form, like the ducts of the sudoriparous glands.

The ducts of the Seb: glands are lined with cone shaped prolongations of the Epidermis—the structure of this lining is the same as that of the ducts of the sudoriparous glands. Sebaceous glands occur in all parts of the body, but are most numerous where friction takes place, and in the face.

Hairs are horny growths from the skin produced by the involution and evolution of the Epidermis:— the involution constituting the follicle in which the hair is inclosed, and the evolution, the shaft of the hair. Hairs differ much both in thickness and in length— in some parts of the body they are scarcely perceptible, whilst in others they are very strong, as on the chin, and very long as on the head—

Microscopical Appearances. When a section of a hair is examined with the microscope, it presents a serrated or reniform appearance and if we examine the hair more closely, we shall find that it is traversed by a central canal—analagous to the pith of some woods. Its central portion is quite transparent, whilst the outer parts are quite opaque. This appearance has been considered by some as constituting a cortical and a medullary substance—

One extremity of the hair is deeply implanted into the skin, and here presents a funnel shape (or conical)— the free extremity is generally split into two or three filaments—

Brand & Todd 87. 88.

The hairs are formed by delicate papillae or pulps analogous to the papillae of the dermis – the hair is by this papillae, secreted in exactly the same manner as the epidermis is formed by the dermis –
First – the papilla secretes a lymphy or albuminous matter, (the blastema) then a delicate cyst is formed, being nourished by the plasma – this is the cyto-blast –
Next the cyto-blast is converted into a true cell, and subsequently a nucleus is formed within this cell, forming a nucleated cell – These latter undergo the same alteration from pressure and other physical causes, as operate in the case of the cells that form the epidermis, and they gradually become lengthened out into hairs –

So far for the cells which compose the principal part of the hair, but those which are situated on the surface, conduct themselves differently – they become arranged after the manner of scales, and their over=lapping gives rise to the roughened appearance presented by the edges of the hair, and it is this which causes the sensation of roughness when a hair is drawn through the fingers –

These rough processes were considered by Leuwenhoeck to be branches from the hair –
The Colour of the Hair, like that of the epidermis depends upon the presence of a peculiar pigment contained within the cells. The albinos hair and irides are devoid of pigment, and hence their name, the hair being perfectly white –
Heusinger and Simon have investigated the formation of hair – the latter examined the

process in a foetal pig. The Epidermis is inflected at various points, forming follicles – in which the pigment granules are deposited, and these deposits assume the characters of the roots of the hair; in a more advanced stage of growth, when the hair is first perceptible, it is doubled on itself so that both ends appear to spring from the follicle, soon however the unattached extremity bursts forth, and after some time, the entire hair is thrown off, and then the permanent hair begins to grow.

The Sebaceous glands are formed in the same way, i.e by inflections of the epidermis -

Chemical Analysis of Hair by Vauquelin -

1 Animal matter - 2 a greenish black oil, in large quantity - 3 a white concrete oil, in small quantity 4 - 5 Phosphate of lime - 6 Carbonate of lime (a trace) 7 Oxide of Manganese 8 iron - 9 Sulphur 10 Silex -

Ultimate Analysis -

Carbon	50 - 652
Hydrogen	6 · 769
Nitrogen	17 · 936
Oxygen Sulphur	24 · 643
	100 · 000

Fair Hair contains least carbon and hydrogen, and most oxygen and sulphur - brown hair most carbon and less hydrogen than black hair, and the smallest quantity of Sulphur -

Plica polonica is a disease of the hair, like the skin of a Rhinoceros - show drawing from Roger -

Nails are horny appendages of the skin, being quite identical in structure with the epidermis and hair. They are formed by a reduplication of the dermis, which extends backwards for a couple of lines - This is termed the matrix of the nail, and the peculiar

relation between it and the nail can be readily seen, in cases where the nails and cuticle become detached from the Dermis from decomposition as in the subjects in the dissecting room –

The matrix is composed of numerous delicate papillae which secrete cells after the manner of the Dermis, in the formation of the epidermis; these also gradually as they are formed push forward those previously formed, and the process goes on ad infinitum.

The upper surface of the nail is convex and polished, and the under surface is concave and attached to the dermis. In this situation the dermis is thickly occupied by papillae, which also secrete cells which add greatly to the thickness and strength of the nail. These papillae are arranged in parallel folds, leaving spaces between the rows, which spaces are also covered by minute papillae.

Beneath the root of the nail and for some distance forward, the papillae are much more minute and less vascular, and this circumstance constitutes what has been termed the lunula, or in common parlance, the feather of the nail.

It is the arrangement of the papillae into ridges that gives the nail the ribbed appearance, it has not only in the human race, but in the lower animals.

Chemical Analysis of Nails – Scherer

Carbon	—	57.089
Hydrogen	—	6.824
Nitrogen	—	16.901
Oxygen } Sulphur }	—	25.186
		100.000

The Skin is an organ of Sensation, Secretion and Absorption. By means of the former quality we are

admonished of the presence of injuries or destructive agents. By the second it is enabled to appropriate the fluids contained in the surrounding medium, and perform perspiratory functions – and it is kept at a regular temperature and in a pliant and soft condition.

Sensibility of the skin is greatest in the pulps of the fingers, which are especially the organs of touch: it is least about the middle of the limbs as in the arm and thigh –

Experiments of Weber. With a delicate compass. When introduced into the pulp of middle finger, both points could be distinctly felt – at a distance of 1/3 of a line. On the palmar surface of the finger 2 lines. On the middle of the breast 20 lines. Cheek 5 lines. forehead 10 lines. On the middle of arm and thigh 30 lines. He also proved that there is a difference in the perception of temperature between different parts. If both hands are immersed in water of the same temperature that in which the left is placed, will feel warmer than the other. If a weak impression be made over an extensive surface of skin, it does not produce so great an effect upon the nervous system, as if a strong impression were made upon a small portion of the skin. If the whole of one hand be put into hot water, it will produce a great impression, whilst to one finger of the other hand it may be quite imperceptible.

Sensibility of the skin alters greatly from disease – It may be greatly depressed or entirely annihilated, or on the other hand, it may undergo great exaltation – Besides the perception of heat and cold, the skin also perceives those modifications of sensation, termed itching, tingling, smarting, pricking, shooting, creeping, tickling, burning, scalding –

By means of Absorption, the skin is enabled to act as an organ of Respiration. this property is not observed in man, but in many of the lower insects, the whole process is carried on through the skin.

If the body be immersed in water at the temperature of 28 Cent: or 82 Fah - it will soon be found to have increased in weight from the absorption of the water. This is still better proved by the appearance in the urine of the salts contained in the bath: thus for instance, Westrumb, discovered the Ferrocyanide of Potassium in the urine of a person, who had taken a bath containing the substance - and D'Arcet found the urine of another to become alkaline after bathing in the Baths of Vichy - Colouring matter such as Rhubarb, has been found in the urine after bathing. If however the bath should be at a higher temperature, than that of the body, the latter will be found to have lost considerably in weight. In the former case, the bath acts as a sedative, in the latter as an excitant.

The absorbent property of the skin is sometimes taken advantage of by the practical physician, to introduce medicines into the skin, - but for this purpose he must select parts of the body, where the skin is thinnest and most tender, and he must likewise use gentle friction. And the medicines must be presented to the skin either in solution in water or in oil. This method has been termed Iatraleptic - yet with the exception of a few medicines, this method cannot be satisfactorily employed, for the cuticle almost completely prevents the introduction of the medicine to the absorbing surface of the dermis, and hence

a second plan has been proposed, viz the Endermic -
This consists in removing the epidermis by means of a
blister, and then the medicinal substance is applied to
the denuded dermis. This plan is adopted in cases
where the patients cannot be got to swallow nauseous
drugs - or after drugs have failed to produce their
effect in the ordinary modes adopted for their adminis-
tration. Of course medicines which require only small
doses can be employed in this way.

The absorbing power of the skin - is unpleasantly proved
by the strangury which sometimes follows the application
of a blister; by the colic and paralysis from lead, and
poisoning from arsenic when applied to a sore.

The hair is kept, pliant and oily, by the secretion
from the sebaceous follicles, which also serves to protect
it from the influence of the air, and other physical
causes. This secretion is most abundant on the face,
forehead, on the trunk, in the armpits and in the
perineum. It is composed of oil globules, stearine
and some pigment globules, together with epithelial
scales thrown off from the lining of the sebaceous
follicle. The secretion varies in different parts of
the body - in some parts it is combined with an
odorous secretion and in others of a peculiar bitter or
acrid matter. Thus the secretion from the peri-
neum contains Butyric acid, and that from the
glands of the Meatus Auditorius externus, contains
a peculiar bitter principle.

Chemical Comp: of Sebaceous matter by Esenbek

Fat	24.2
Osmazone with traces of oil	12.6
Watery Extractive	11.6
Albumen & Caseine	24.2
Carbonate of lime	2.1
Phosphate of lime	20.0
Carbonate of magnesia	1.6
Acetate & Muriate of Soda & loss.	3.7
	100.0

Perspiration. By this function the skin acts as a regulator of the heat of the body, and as a purifier of the Blood –

Two kinds of perspiration, the insensible and the sensible – The insensible persp^n. is derived, partly from the secretion of the sudoriparous glands, and partly from the evaporation which takes place from the epidermis –

Lavaisier and Seguin estimate the amount of both the sensible and insensible perspiration as averaging twenty three ounces, whilst they estimate the exhalation from the lungs at twenty one ounces –

Dalton makes the latter 5 times greater than the former.

The amount of secretion is regulated by the state of atmosphere and the degree of temperature – also by the existence of any kind of stimulation acting upon the skin, and by the effects produced by various causes upon the nervous system –

If with a high temperature, the atmosphere be also dry – the body perspires freely, and does not suffer much from heat; this is promoted too, by the air, coming against the body in currents – But, if with a high temperature, the atmosphere be likewise loaded with moisture, the skin cannot perspire, and the entire body then suffers from pungent heat –

The influence of stimulation in arresting perspiration is exemplified in fevers; the familiar effects of

exercise, the warm bath and diaphoretics -
Examples of the influence of the nervous system -
1 Hot stage of fever. 2 emotions of the mind, as fear, anxiety, and also 3 syncope -

The secretion from the skin, varies according to the amount secreted from the kidneys and from the lungs. Instances - 1st hot weather, much perspiration and little urine - in Cold weather the reverse - When the one is checked the other is increased. In Phthisis much sweating, little exhalation from the lungs - in Diabetes much urine, little sweating. In Cutaneous fevers, no persp^n and very great derangement of the urinary organs, in some cases, as in Scarlatina - Mons: Fourcault's experiments go to prove that if the perspiration be arrested, the animal will die from asphyxia.

The Exper^t of M. M. Becquerel and Breschet, though they were undertaken, with the idea, that if persp^n could be arrested, internal heat would be induced; the results were quite the opposite - After the application of a thick Varnish to the body of a rabbit, and adjusting their electro-thermic needles, they found the temperature of the deep muscles, in half an hour to be reduced from 30° to 32°; in another half hour, to 24.5; and in a third half hour, it stood at only 3 degrees above the temperature of the Atmosphere 17°. So that the temp of the animal fell 18° and then it died.

Chemical Comp of Perspiration - Water, Nitrogen, Osmazome, Carbonic acid with its salts, Carbonates of

da and lime, sulphate of soda, salts of potash and
xide of Iron.

Dogs do not perspire from the skin, they perspire
om the tongue.

Dr Dalton estimates the quantity of Carbon elimi=
nated from the skin as 1/20 of the entire secretion
from this organ. The odour of the perspiration,
depends upon the presence of the osmazone and ammo
nia, whilst its acid properties are due to the presence
of the lactic acid –

Cartilage — Fibro=Cartilage

G. D. Gibb MD

7 June 1851

To illustrate

Figures 13. 14. 15 & 16 from Todd
" 17 from Todd.
use Microscope to show structure

Write this lecture over, and include the whole of the 2 Chapters in Todd, on Cartilage and Fibro Cartilage –

Cartilage is extensively used in the animal frame and is one of the simplest of the textures: like the adipose tissue it approaches very closely to the cellular tissue of the vegetables.

It is one of the first tissues that appears as a distinct structure in the developement of the foetus, and it is of it, that the internal skeleton is at first composed. The Rudimentary skeleton of the cephalopoda consists of it, and in one class of fishes (the Cartilaginous, as the shark and ray) the skeleton is entirely composed of it. # In the higher animals, cartilage forms the nidus for the deposition of bone, it is then termed the Temporary Cartilage - At an early period, the whole skeleton is composed of cartilage; and for a considerable period after birth, the extremities of the long bones are chiefly composed of cartilage.

There is however another cartilage employed in the economy which is not liable to be converted into bone; this is called the permanent Cartilage - When this permanent cartilage occurs in joints: it is called the Articular cartilage, or the cartilage of incrustation - And when it occurs in the walls of cavities, Membraniform or non-articular.

The articular cartilages present themselves either in the form of thin laminae lying between the two bones, as the sacro-iliac synchondrosis, or between the bones of the pubis, or the bones of the head - Or, as in the case of the Diarthrodial joints, they occur in the extremities

In the crab it forms the first attempt at an exter: shell -

of the bones, ~~extending~~ entering into the formation of the joints - as in the case of the femur, tibia, all of which are coated with a layer of cartilage, moulded to the shape of the articular surfaces.

The membraniform cartilages are not connected with parts subject to motion, but are connected with the orifices of canals, ducts &c, where they are required to keep permanently open, these canals. An instance of this is exhibited in the external ear, and also in the Eustachian tubes - in the nostrils, eyelids, and in the larynx, trachea and bronchial tubes -

A third division of Cartilage is into the Accidental of some authors, consisting of abnormal products as false bodies in Joints.

Physical Characters - Cartilage is in colour of various hues, from azure, or pearly white, to a whitish yellow. The temporary and articular varieties, present the former colour; the membraniform, for the most part, the latter. Elasticity, flexibility and considerable cohesive power are the chief physical properties of this texture, and in the first of these qualities, consists its great value. Cartilage is not brittle, nor easily broken, it may be bent at right angles without breaking -

Structure of Cartilage. The simplest forms of cartilage consist merely of nucleated cells, in this respect closely resembling the simple forms of cellular tissue in plants. The cells are large, roundish, and ovoidal, and more or less flattened from their being packed in contact. (Figure) - Each with a small transparent nucleus in its centre, containing within it a minute granule or

nucleolus. This simple form of cell is found in the rudimentary spinal column of the human embryo, and in the chorda dorsalis of the Cartilaginous fishes, and in the lamprey. (Figure 13)-

In other cartilage however the cells are imbedded in intercellular substance.

In temporary cartilage the cells are very numerous and are placed at regular intervals. They are also for the most part round or oval. Their nuclei are for the most part also minutely granular. When ossification begins, the cells, which hitherto were scattered without definite arrangement, become disposed in clusters or rows, the ends of which are directed towards the ossifying part. These will be described when we speak of bone.

In articular cartilage the cells are oval or roundish, often disposed in small sets of 2. 3 or 4 irregularly disseminated through a homogeneous matrix, which is more abundant than in the temporary cartilage. *
(Show Figure 14 [illegible])-

A pavement of nucleated epithelial particles has been described by Henle to exist on the free surface of articular cartilage. In the foetus this may be readily seen, but it cannot (according to Todd) be so easily seen in the adult.

The Cartilages of the Ribs, which occupy an intermediate place, between the membraniform and the articular, possess cells of the largest size found in cartilage, being from $\frac{1}{650}$ to $\frac{1}{430}$ of an inch in diameter. Many of them contain two or three nuclei, with some

* see Todd p 90, if necessary-

oil globules. (Figure 15

In these Cartilages, the intercellular substance is very abundant, and presents a fibrous appearance, in which the fibres are parallel. This condition is best marked in old subjects.

In the true membraniform cartilages, such as the Thyroid, the cells are very numerous in proportion to the surrounding substance, which is consequently in small quantity. The Thyroid, Cricoid, and the rings of the trachea appear composed of cells "huddled" together in a very promiscuous manner. (Figure 16

In the Cartilages of the Ear the cells are extremely small and very close to each other; in shape they are very uniform and vary in size from $\frac{1}{1300}$ to $\frac{1}{900}$ of an inch. When examined with a high power it has a sieve like appearance.

The Membraniform cartilages are invested by a layer of membrane called the perichondrium. This structure is of use, in conveying the blood-vessels to the cartilage; it adheres intimately to the fibrous structure, and answers the purpose of the periosteum of bone, and is identical with that structure in the temporary cartilages. It is the nidus for the nutrient vessels, and also serves to give attachment to the muscles. It is best marked on the Cartilages of the Ribs. Its great toughness is well exhibited in fractures traversing the cartilages, when it will often remain ~~in contact~~ intact.

The articular cartilages are supplied with blood

For page 7

although the fibres of which each layer is composed are directed obliquely from above downwards, and the direction of the fibres of one layer is such as to decussate with those of the layer immediately behind it.

⊗ This arrangement belongs to rather more than the outer third of the disc; the central portion is occupied by a soft, yielding, pulpy matter, which, when a disc is cut horizontally, rises up considerably above the surrounding level. This soft mass consists of a few bundles of white fibrous tissue (wavy fibres), with numerous cells nucleated, very variable in shape and size, loosely interspersed. It is girt by the surrounding vertical fibrous layers and their interposed cartilaginous lamellae and also compressed by the vertebrae between which it is placed; the pulpy matter being separated from immediate contact with the surfaces of the vertebrae by the interposition of thin layers of cartilage.

In the menisci the white fibrous tissue predominates considerably at their circumferences, while the cartilage chiefly abounds in the centre. Those of the knee joint and temporo-maxillary joint are the densest: that of the sterno-clavicular is softer and more cartilaginous.

by the vessels of the bone with which they are connected, and by vessels from the synovial membrane.

Vessels of Cartilage. Cartilage has been styled a non-vascular substance, i.e. large portions of it, in all its varieties, exist, entirely destitute of blood-vessels; but when more than the eighth of an inch in thickness, vessels can be readily traced through canals contained in its interior. These canals are somewhat tortuous, and contain a delicate extension of the peri-chondrium. They may be regarded as so many involutions of the outer surface of the cartilage.

The Bloodvessels of the Membraniform Cartilage, are not so numerous.

No Bloodvessels can be found in articular Cartilage. They cannot be injected, nor can any be detected with the highest microscopic powers.

Nerves exist in Cartilage, and Lymphatics are presumed to exist.

* and its appearance differs with the quantity of that texture that is mingled with it. Its consistence also varies for the same reason;

⊙ When examined microscopically, fibro-cartilage is found to consist of bundles of wavy fibres, with the cells or corpuscles of cartilage occupying the spaces formed by the interlacement of the fibrous tissue. This interlacement is often very intricate, and calculated to increase the strength of the structure in those directions in which the greatest toughness is required.

<u>Physical & Vital properties</u>. To the strength & density of fibrous tissue, fibro-cartilage adds the elasticity of cartilage; it is more variously flexible than the latter tissue, so that it will not crack when bent too much. Its sensibility is low, & it is devoid of vital contractility.

<u>Vessels & nerves</u>. Its vessels are few, and are derived from the textures with which it is in immediate contact or connexion, as the synovial membrane or periosteum. Nothing is known respecting its <u>nerves</u>, if indeed it possess them.

<u>Chemical Composition</u>. Fibro-cartilage contains water, when deprived of it by drying, it shrivels up, and becomes hard & yellow. It yields gelatine in abundance on boiling.

<u>Forms of Fibro Cartilage</u>.

Fibro=Cartilage.

is composed of white fibrous layers, or tissue, with cartilage cells intermixed through it, in varying proportions, as It is principally employed in the construction of joints, & contributes to their perfection, at once by its strength and its elasticity - but as it is also, to a limited extent, used for other purposes, it may be conveniently divided into 1 Articular 2 Non-articular -

Fibro-cartilage resembles very closely the membraniform cartilages, and they have been confounded with these latter by Bichat and subsequent writers.

Colour, white, with a slight tinge of yellow; it is interspersed by the shining fibres of white fibrous tissue*. In some places it is dense and strong: in others it is soft and yielding, and almost pulpy - ⊙

~~It is also elastic. Its sensibility is low, and it is devoid of vital contractility. It gets blood vessels from the synovial membrane or periosteum with which it is in contact. It is not known if it possesses nerves.~~

The articular Fibro Cartilage is that which is found most extensively and is divided into 3 classes.

1 as Discs, interposed between osseous surfaces, and usually adherent to both bones. ex. intervertebral discs, and the interpubic fibro cartilages -

2 as Laminae free on both surfaces (placed in the cavity of diarthrodial joints between articular surfaces of bones.) as the semilunar cartilages of knee joint: the interarticular cartilage of the lower jaw: sterno-clavicular articulation: between scaphoid & lunar, & lunar & cuneiform bones. These are the menisci of authors.

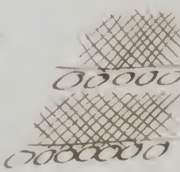
for page 7

In intimate structure it resembles the articular forms.

3 As triangular edges to the glenoid and cotyloid cavities, of the shoulder and hip joint. these are styled Circumferential. (or oval) –

The intervertebral discs consist of white fibres externally with cells beneath –

These concentric layers of white fibrous tissue, are placed vertically between the surfaces of the vertebrae, decussating with one another #. each pair of layers of fibrous tissue is separated by a lamina of cartilage. (Figure 7 *



The circumferential fibro-cartilages, contain a great quantity of fibrous tissue. The non-articular form is deposited on the surfaces of the grooves of bones, which lodge tendons; as for ex. the groove for the tibialis posticus – #

Reparation and reproduction – Fibro-cartilage heals by a new substance of a similar texture. This sometimes unites bone, when bony union does not take place –

* page 95 Todd, if necessary –

Bones

J D Gibb MD

12th June 1857

To illustrate

Bones deprived of animal matter -
do do of earthy do
Phosphate of lime.
Sections of bones, head of femur &c
bone with periosteum.
drawing of minute structure of bone from Wilson
drawings in Todd - Figs 18. 19. 20. 21. 22. 23.
28. 29. 30.

Modify a little and add a page or 2.

Bones constitute in the divisions of animal textures, the hard parts.

Amongst the invertebrated classes, there are hard parts, but they are differently constituted from those of the higher animals; they answer the same purpose, viz: to afford firmness and stability to the frame, to protect important parts and to give attachment to muscles.

Bony matter, presents itself either externally, or internally. In the polypiferae, Crustacea and conchifera the shells answer the purpose of an internal skeleton in the higher animals. The skeleton of the higher animals is internal; and is covered by muscles and other soft parts. The first arrangement of this kind is found in the Cuttle Fish. It is composed almost entirely of carbonate of lime and is highly prized as a Dentifrice. In these animals the internal skeleton is chiefly of use in protecting the nervous system. The skeletons of the lowest forms of fish are the next in point of organization - they are composed for the most part of dense cartilage, with earthy matter sparingly deposited through it. This is the nearest approach to the skeletons of the higher classes -

Bone forms the skeleton of osseous fishes, reptiles birds and the mammalia - it forms levers - organs of support to the body, and protects the important and vital organs.

Physical Properties. Bone possesses great hardness, density, a whitish colour, opacity and considerable elasticity. Bones are the only hard substance in the body. The specific greater than any other structure. The coulour which Todd describes as whitish, is by other authors said to be pale rose in the adult, inclining to red in early life, and a yellowish white in old age. They become white when macerated and deprived of oily and bloody matter. Besides being opaque they are slightly diaphanous. They possess flexibility as well as elasticity. The bones of children are very flexible and often only partial fractures occur in young subjects. Elasticity is shown in the ribs; boys make bows from the ribs of a horse.

Bone contains less water than any other structure in the body, and even this can be readily removed by evaporation, hence its great hardness.

Bone is composed of an animal and an earthy matter, which can be very readily removed by simple processes. If we steep a portion of bone, in dilute muriatic or nitric acid, we decompose the earthy matter (phosphate of lime) and procure a soluble salt, the muriate of lime, which separates from the animal matter, leaving the latter intact. It will now be seen that the bone still retains its shape, and if the bloodvessels should have been injected previously, they will now become very manifest.

If we subject a bone to a strong heat in a crucible, we can completely remove the animal matter; and though the bone will retain its figure, yet the slightest touch will crumble it, into atoms—

We can also extract the animal matter by means of boiling, in a Papins Digester. The jelly or gelatine procured for edible purposes, is obtained by the rough process of boiling in a common vessel.

A due proportion of animal matter gives bone a certain degree of elasticity; and were it not for a due proportion of earthy matter, bone would be too flexible, as can be easily seen in bone deprived of this matter. This is the cause of the great elasticity and liability to fracture in bones of individuals of different ages.

Old bones abound in earthy matter - perhaps they are also defective in the quality of this matter. Hence, old bones, in which the animal matter is less abundant, as well as perhaps defective in quality, are more brittle than young ones, and old persons are more liable to fractures.

Table of Schreger showing the relative proportions of earthy and animal matter in bones of different ages.

	child	adult	old
Animal Matter	47.20	20.18	12.2
Earthy matter	48.48	74.84	84.1
	95.68	95.02	96.3

So that in the child the earthy matter forms nearly one half the weight of the bone, in the adult is equal to four fifths, and in the old to seven eights -

Observations of Dr J. Owen. Rees -

According to these observations, the bones of the extremities contain more earthy matter than the bones of the trunk; and the bones of the upper extremity contain more than the bones of the lower extremity: the

Humerus contains more than the radius and ulna; and the femur more than the tibia and fibula; while the bones of the forearm do not contain more than the tibia and fibula - The vertebrae, ribs and clavicles are similarly constituted. The Ilium has more earthy matter than the scapula and sternum: the bones of the head have more of this material than those of the trunk. The same law holds good with respect to the foetus.

In the disease called Rickets, so common in the children of scrofulous parents, and in the ill nourished ones of the lower orders, there is a deficiency of earthy matter, the bones bend under the weight of the body. The curves which they ~~generally~~ take are generally speaking, "an aggravation" of the natural curves of the bones: thus in the Femur it is forwards; the tibia forwards and outwards & also the fibula.

When the healthy deposition of earthy matter, returns the bones acquire both hardness and strength, but they never regain their natural shape.

In the tibia of a rickety child Dr Davy found in 100 parts, 74 parts animal matter, and 26 earthy and Dr Bostock found in the vertebra of a similar subject 79.75 animal and 20.25 earthy -

Brittleness of bone in old age arises from extreme quantity of earthy matter - this however is not a morbid process.

Malignant disease of Bone - as Cancer & Fungus Haematodes - the bones are very brittle - this arises from Malities assium - every part of the bone seems tainted, the animal as well as the osseous. The bone readily

The proportion of earthy and animal matter is nearly the same in the Mammalia, Birds, Reptiles and Fishes - they all have a predominance of the animal matter -

cuts with a knife it is so soft, and it is full of oil.

Bones possess great powers of preservation not only in their earthy but also in the animal part of their constituents. Cuvier states that even Fossil bones contain a considerable amount of cartilaginous matter. Bichat found an abundant amount of Cartilage in a clavicle that had been exposed to the weather for ten years in a church-yard at Clamart Paris - And Dr Davy has analised a Roman frontal bone dug from Pompeii & found 35.5 animal - 64.5 earthy - and in a tooth of the antediluvian Mammoth 30.5 animal & 69.5 earthy matter.

The animal matter is composed of cartilage, blood vessels and medullary membrane and fat. Berzelius states that the cartilage can be resolved into pure gelatine after 3 hours boiling, and we obtain this, there are only four grains out of the 100 to account for the blood vessels and other animal matter.

Earthy Matter of Bone consists of Phosphate & Carbonate of lime - with a small quantity of Phosphate & Carb of magnesia. The Phosphate of lime forms the principal part of the earthy matter - according to Berzelius 51.04 in 100 parts of bone. #

Differences observed in making a Section of Bone. We find 2 varieties of bony substance; — one part, hard compact & close, always situated on the exterior of the bone, and is called also the vitreous or cortical portion - the other loose, reticular and spongy, enclosing spaces or cells which communicate freely with each other, and which being called Cancelli,

give to this kind of tissue the name of Cancellated. This portion of the bone is formed by the crossing of the fibres in every direction. But in point of fact there is no difference in structure between these two parts - the outer layer of bone would become loose & cancellated like the inner, were it unravelled out - And the inner portion would become dense, hard, compact & heavy like the other, were it subjected to pressure. With a good glass, its structure presents exactly the same characters as the cancellated portion. (Figure)

Classification of Bones -

1 Long Bones 3 Flat
2 Short 4 Irregular

1 The Long or Cylindrical bones, possess a shaft & 2 extremities & are generally found in the extremities. Shaft is more prismoid or triangular in form than cylindrical, it is hollow and contains medulla. The long bones are, clavicle, humerus, radius & ulna, femur, tibia & fibula and ribs -
2 Short bones are of nearly equal length, breadth and thickness. they have the characters of long bones, excepting length - Metacarpal & metatarsal bones, phalanges of fingers & toes -
3 Flat or broad bones, are composed of 2 layers of dense bone with intermediate cellular substance. Cranium, scapula, os innominatum, bones enclosing the great cavities of the body - Speak of Tables of skull & diploë -
4 Irregular or mixed bones - Irregular in shape & size. Composed mainly of cancellated structure, covered by compact. Vertebrae, carpal & tarsal, sesamoid, certain bones of the face, as sphenoid, ethmoid, temporal, sup & inf max'y, palate, inf turb.

The greatest variety exists in the whole of these classes of bones, some possessing eminences and depressions, tuberosities tubercles, spines, cristae, fossae, cells, furrows, grooves, fissures, pulleys &c. Long bones are compressed and thin in their shafts, so as to hold the bellies of muscles; they are expanded at the ends to form the joints, to give strength to the limb & for the attachment of muscles and ligaments, and for transmission of vessels.

All the bones are covered with periosteum externally, & medullary membrane internally - fibres are longitudinal in the long bones, and web like in short & other bones.

Structure of Bone) - Bone is a dense, compact and homogeneous substance. (basis substance) filled with minute cells or lacunae, (corpuscles of Purkinje) which are scattered numerously through its structure. The basis substance of bone is subfibrous and obscurely lamellated, the lamellae being concentric in long and parallel in flat bones; it is traversed in all directions, but especially in the longitudinal axis, by branching and inosculating canals, called Haversian canals, Hassall 222 from Clopton Havers their discoverer, which give passage to vessels and nerves, and in certain situations the lamellae separate from each other, and leave between them areolar spaces (cancelli) of various magnitude. The lamellae have an average diameter of 6000 of an inch, and besides constituting the general structure of the basis substance, are collected concentrically around the Haversian canals, and form boundaries to those canals of about 250 of an inch in thickness. The number of lamellae surrounding each Haversian canal, is commonly 10 or 15,

and the diameters of the canals have a medium average of $\frac{1}{600}$ of an inch. The cancelli of bone like its compact substance have walls which are composed of lamellae, and such is the similarity in structure of the parts of bone, that the entire bone may be compared to an Haversian canal of which the medullary cavity is the magnified channel; and the Haversian canals may be likened to elongated and ramified cancelli.

The Haversian canals are smallest near the surface of a bone, and largest near its centre, where they gradually merge into cancelli; by the frequent communications of their branches they form a coarse network in the basis substance.

The cells of bone, the lacunae, or corpuscles of Purkinje, are thickly disseminated through the basis substance; they are irregular in size and form, give off numerous minute branching tubuli which radiate from all parts of their circumference, and in the dried state of the bone contain merely the remains of membranous cells and some calcareous salts. In the living bone the cells and their tubuli are probably filled with a nutritive fluid holding calcareous salts in solution. The form of the cells is oval or round and more or less flattened, their long diameter corresponds with the long axis of the bone, and their tubuli cross the direction of the lamellae and constitute a very delicate network in the basis substance by communicating with each other, and with the tubuli of neighbouring cells. The tubuli of the cells nearest the

Haversian canals terminate upon the internal surface of those cavities. The size of the cells varies in extreme measurement from $\frac{1}{5000}$ to $\frac{1}{600}$ of an inch in their long diameter, an ordinary average being $\frac{1}{1000}$; the breadth of the oval cells is about one half or one third their length, and their thickness one half their breadth. They are situated between the lamellae, to which circumstance they owe their compressed form.

The ultimate substance of bone appears to be usually granular; the granules are stated by Mr Tomes to be often very distinctly visible, without any artificial preparation, in the substance of the delicate spicula of the cancelli, when viewed with a high power, and to be made very evident ~~from~~ by prolonged boiling in a Papin's digester. (Figure 21 obtained in this way.) They vary in size from $\frac{1}{6000}$ to $\frac{1}{14.000}$ of an inch; their shape is oval or oblong, often angular; and they cohere firmly together, possibly by the medium of some second substance. A frequent appearance of the granular texture is well represented in Fig. 22.

Periosteum. In the fresh state bones are invested by a dense fibrous membrane called the periosteum. Bone is covered every where by it, excepting where there is enamel, cartilage or fibro-cartilage, as on the articular extremities. The periosteum of the bones of the skull is termed pericranium; and the analogous membrane of external cartilages perichondrium.

Its external surface is in contact with a great variety of parts; muscles, synovial bursae, mucous membranes, vessels, nerves. &c

It is very vascular in the young and of a red colour.

Uses of the periosteum.

1 For modelling the bone –
2 To prevent attrition between muscle & bone –
3 To strengthen the junction between the epiphyses, which are connected by periosteum –
The connection between the epiphyses has sustained a weight of 500 lbs without separation –
4 To connect tendons and ligaments to bone –
5 To sustain the blood vessels.

The destruction of this membrane produces the death of the bone, forming the disease called Necrosis.

The Medullary Membrane, resembles the pia-mater in structure. It acts as an internal periosteum, and lines the interior of the medullary canal of long bones, the Haversian canals, the cells of the cancelli, and the cells of short, flat and irregular bones.

The medullary canal, Haversian Canals and cells of long bones, and the cells of other bones, as those in the spongy extremities of long bones and in the areolae of the shaft, are filled with a yellowish oily sub=stance, the Medulla, which is contained in a loose areolar tissue formed by the Medullary membrane.

Nutritious Artery is for the marrow, as it is through the ramifications of its branches that the medulla

is secreted, and the changes required by nutrition occur.

Uses of Medulla 1st Internal periosteum, affording a bed for the ramification of vessels –

2nd A store for starvation –

Marrow is not essential to bone – for the young contain less than the old – in the foetus the medullary canal contains jelly – and in birds air occupies the cavities of the bone –

Arteries – Three sets of arteries are found in long bones

1st enter the Nutritious foramina –

2nd enter from the periosteum –

3rd enter at the extremities of the bones –

Veins – In many of the large and flat bones, veins are exceedingly capacious, and occupy a series of [2]canals tortuous[1] of remarkable size and very characteristic appearance. These are well shown in those passing through the bones of the head in the diploe – see Figure 20

They have only one coat, and adhere intimately to bone. The arteries & Veins of bone usually occupy distinct Haversian canals, of these the venous are the larger

Nerves – Are seen to enter along with the nutritious artery – the proof of their existence is shown by the pain of diseased bones – e.g. abscess in bone. &c –

Lymphatics – are shown to exist, in the regeneration of bone in necrosis, when a considerable portion of the dead bone is absorbed and removed –

Developement of Bone - Bone in its earliest state is composed of an assemblage of minute cells, constituting the simplest form of cartilage, which are soft and transparent, and are disposed within the embryo in the site of the future skeleton. From the resemblance which the soft tissue bears to jelly, this has been termed the gelatinous stage of osteo-genesis. As development advances, the cells, heretofore loosely collected together, become separated by the interposition of a transparent intercellular substance, which is at first fluid, but gradually becomes hard and condensed. The cartilaginous stage of osteo-genesis is now established, and cartilage is shown to consist of a transparent matrix, having minute cells disseminated at pretty equal distances and without order through its structure. Coincident with the formation of cartilage is the development of vascular canals in its substance, the canals being formed by the union of the cells in rows, and the subsequent liquefaction of the adhering surfaces. The change which next ensues is the concentration of the vascular canals towards some one point; for example, the centre of the shaft in a long, or the mid-point of a flat bone, and here the punctum ossificationis or centre of ossification is established. Figures 38 & 39

During the formation of the punctum ossificationis, changes begin to be apparent in the cartilage cells. Originally they are simple nucleated cells ($\frac{1}{5000}$ to $\frac{1}{2000}$ of an inch in diameter), having a rounded form. As growth proceeds, they become elongated in their

figure, and it is then perceived that each cell contains two and often three nucleoli around which smaller cells are in progress of formation. If we examine them nearer to the punctum ossificationis we find that the young or secondary cells have each attained the size of the parent cell ($\frac{1}{2000}$ of an inch); the membrane of the parent cell has disappeared, and the young cells are separated to a short distance by freshly effused inter=cellular substance. Nearer still to the punctum ossi=ficationis a more remarkable change has ensued, the energy of cellule reproduction has augmented with prox=imity to the ossifying point; and each cell in place of produ=cing 2 gives birth to 4, 5, or 6 young cells which rapidly destroy the parent membrane and attain a greater size ($\frac{1}{1500}$ of an inch) than the parent cell, each cell being, as in the previous case, separated to a slight extent from its neighbour by intercellular substance. By one other repetition of the same process, each cell producing 4 or 5, or 6 young cells, a cluster is formed, containing from 30 to 50 cells. These clusters lie in immediate relation with the punctum ossificationis; they are oval in figure (about $\frac{1}{200}$ in length by $\frac{1}{500}$ in breadth), and placed in the direction of the longitudinal axis of the bone. The cells composing the cluster lie transversely with regard to its axis. In the first instance they are closely com=pressed, but by degrees are parted by a thin layer of intercellular substance, and each cluster is separated from neighbouring clusters by a broader layer ($\frac{1}{3200}$ of inch) of intercellular substance. Such are the changes which occur in cartilage preparatory to the formation of bone.

Ossification is accomplished by the formation of very fine and delicate fibres within the intercellular substance: this process commences at the punctum ossificationis and extends from that point through every part of the bone, in a longitudinal direction in long bones, & in a radiated manner in flat bones. Starting from the punctum ossificationis, the fibres embrace each cluster of cells, and then send branches between the individual cells of each group. In this manner the network, characteristic of bone, is formed, while the cells by their conjunction constitute the permanent Areolae and Haversian Canals

Cartilaginification is complete ~~by~~ in the human embryo at about the 6th week, and the first point of ossification is observed in the clavicle at about the seventh week. Ossification commences at the centre, & thence proceeds towards the surface; in flat bones, the osseous tissue radiates between two membranes from a central point towards the periphery, in short bones from a centre towards the circumference, and in long bones from a central position, diaphysis, towards a secondary centre, epiphysis, situated at each extremity. Large processes, as the trochanters, are provided with a distinct centre of development, which is named apophysis.

Growth of Bone ~~takes~~ in length takes place at the extremity of the diaphysis, and in bulk by fresh deposition on the surface; while the medullary canal is formed and increased by absorption from within.

The growth of long bones in the longitudinal direction, is the most active, and continues till adult age. Hales and Hunter both inserted metallic substances along the shaft of a growing bone, in a young animal, at a certain distance apart; and found after an interval of time, that the distance remained the same, or nearly so, while the extremities of the bone were much farther apart, thus proving that the principal growth had taken place near the extremities.

The increase in dimension or bulk, by an accession of new osseous substance on the exterior of bones; this new substance consisting not merely of new laminae, but of new systems of laminae; has been best proved by the experiments with madder.

Duhamel, Hunter & others have performed multiplied experiments with this substance.

In very young animals, a single day suffices to colour the entire skeleton, apparently in a uniform manner: in these there is no osseous material far from the surface vascular. But if we make a transverse section of one of the long bones so treated, we observe the deepest, or even the only colour, to be really on the vascular surface; the Haversian canals are each encircled by a crimson ring. (due to Mr Tomes.

Now madder given to half-grown animals colours the long bones most deeply in the interval between the shaft and extremities and on the surface of the shaft.

When madder is given at intervals, the tints in the bone are interrupted; the layers in course of formation during its administration are coloured,

while those formed during the intervening periods are colourless.

Bone also increases in size by the dilatation of the primary Canalli and Haversian canals in the central parts of the bone - proved by the following experiment.

Duhamel placed a ring of silver round a bone of a young pigeon, without injuring the periosteum. After some time, during which the bone had increased in diameter he found the ring in the Medullary canal, which had acquired a capacity equal to the previous diameter of the whole shaft.

Callus describe it - in fractures -

The Muscles No. 1

WD Gibb MD

14th June 1857

To illustrate

drawings from Todd - all of them
Figs 36. 37. 38. 39. 40. 41. 42. 43. 45. 46. 47. 48

Muscles -

The principal movements of the body and all those by which locomotion is effected, are performed by means of a tissue termed *muscle*, endowed with the power of contracting and consisting chemically of *fibrine*.

Muscles have been divided into 2 kinds -

1st The Voluntary or striped muscles

2nd The Involuntary or unstriped muscles -

The *voluntary* muscles perform all the motions of the will, and are situated externally; they are also called the muscles of animal life -

The *involuntary* muscles again, act independantly of the control of the will, and are situated internally; they are designated muscles of organic life -

The elementary fibres of the *voluntary* muscles are connected to one another by areolar tissue. These fibres are arranged in sets parallel to one another and they form organs generally solid and elongated.

The fibres of *Involuntary* muscles, cross over one another and interlace at various angles, and are always as membranous organs, enclosing cavities.

Muscles have abundance of arteries and veins lying between their fibres. They have also an abundance of nerves

The striped muscles, or those of animal life, include the whole class of voluntary muscles, the heart, the muscular tissue of the pharynx and upper part of the oesophagus. The lymphatic hearts of birds and reptiles, and the stomach and intestines of some fish.

The voluntary muscles are composed of fleshy bundles of fibres inclosed in coverings of fibro-cellular tissue, by which each is at once connected with, and isolated from those adjacent to it. Each bundle is again subdivided into smaller ones, similarly ensheathed & similarly divisible; and so on, through an uncertain number of gradations, till just beyond the reach of the ~~natural~~ unaided eye, one arrives at the primitive fasciculi or the muscular fibres peculiarly so called.

The length of the striped fibres is usually about that of the muscle to which they belong, thus in the sartorius they often exceed 2 feet in length, while in the stapedius they are not two lines. They vary in diameter from $\frac{1}{60}$ to $\frac{1}{1500}$ of an inch, being largest in crustacea, fish and reptiles, where their irritability is enduring and smallest in birds, where it is most evanescent. The fibres are not cylindrical but flattened more or less by being closely packed together - small interspaces are left for the passage of the capillary blood vessels along the angles of junction and sometimes between the contiguous sides. (Figures 8 - 1.

the breadth of these fibres in man varies from $\frac{1}{200}$ to $\frac{1}{500}$ of
an inch; their most striking though not constant
characteristics are their pale yellow colour and their
being marked with <u>transverse</u> and <u>longitudinal</u> striae.

The fibre always presents, upon and within it,
<u>longitudinal dark lines</u>, along which it will generally
split up into fibrillae; but it is by a fracture alone
that such fibrillae are obtained. they do not exist
as such in the fibre. If a separation is caused
along the <u>transverse dark lines</u> again which is caused by
violence, a cleavage into discs is obtained, and
not fibrillae. If there were a general disintegration
along all the lines in both directions there would
result a series of particles which may be termed
<u>primitive particles</u> or <u>sarcous elements</u> the union
of which constitutes the mass of the fibre. These ele-
mentary ~~fibres~~ particles are arranged and united together
in the two directions. All the resulting discs as well as
fibrillae are equal to one another in size, and contain
an equal number of particles. The same particles com-
pose both. Figure 37.

Muller, Schwann, Lauth and others consider with
Todd & Bowman that the cross stripes of the fibre are
formed by the apposition side by side of the dark
points seen on the separated fibrillae; but some believe
these stripes to be present only on the surface of the
fibre, and to be formed by the spiral windings of a filament.

that the stripes are not caused by a structure distinct from the fibrillae, and present only on the surface of the fibre, is evident from the following facts:

1 That a transverse section of a fibre shews it to be solid, and not hollow and is filled with sarcous elements; and that the ends of fibrillae as seen on the section, exist throughout its interior just as on its surface. Figure 38 - n 3 -

2 That fibrillae taken from any part of a fibre are marked with light and dark points corresponding in distance and are with the transverse ~~f~~ stripes of the fibre -

Two appearances present themselves in striped fibres: In some parts the cross stripes are perfectly rectilinear or if curvilinear, parallel in their course.

In other parts, these stripes do not extend across the fibre, but are more or less interrupted, forming zigzags and enclosing spaces of a great variety of shapes and size, in concert with the longitudinal stripes. In such specimens we see the semblance of spirals, but none of the sarcous elements are actually arranged in a spiral manner.

In figure 39 n 4 is represented the border of some fibres, from which several of the sarcous elements have been removed accidentally by maceration in weak spirit. The remaining ones project in lateral series, evincing their adhesion to one another in that direction, and the non-existence of any spiral arrangement.

The size of the particles composing the fibre

⊙ These herniae cause a derangement of the protruded particles and the destruction of their lateral parallelism. The result of which is the production of the most beautiful and varied curves intersecting one another, very similar to those already spoken of on the injured febre, and wearing a very plausible aspect of spirals. Same Figure.

may be measured in one direction by the transverse stripes formed by their union.

The following average, deduced from numerous observations, shews great uniformity in this respect.

In the Human subject	$\frac{1}{9400}$
" Mammalia generally	$\frac{1}{10900}$
Birds	$\frac{1}{10400}$
Reptiles	$\frac{1}{11500}$
Fishes	$\frac{1}{11100}$
Insects	$\frac{1}{9500}$

Sarcolemma is a transparent, delicate, but tough and elastic membrane, which isolates the fibre from all other structures. It forms a tubular sheath for the striped fibre, enclosing and adhering to it. In general it has no appearance of any kind of structure, but faint indications of filaments may be detected. It occasionally has small corpuscles in contact with it.

This membrane is the same as described by Wilson under the name of myolemma. It may be seen stretching between the separated fragments of a fibre which has been broken within it, for its toughness will often resist a force before which its brittle contents give way. Figure 4 & 5

If the fibre be immersed in acid,* it swells, often so suddenly as to burst the sheath in several places and protrude in the form of hernia small. Fig. 6

* or liquor potassae

Again the sarcolemma may be seen raised in the form of vesicles from the surface of the fibre, in certain states of contraction in water. By one or more of these modes of demonstration, we know that this isolator of the sarcous tissue invests the striped elementary fibre of voluntary muscle in all animals. Its existence is as yet doubtful in the heart.

Union of tendons & Muscular fibres. Every fibre is attached by its extremities to fibrous tissue, or to some tissue analogous to it. The old opinion that the sarcolemma is prolonged over the whole fibre from end to end as its cellular sheath, is incorrect.

It is difficult to isolate a muscular fibre, with the tendinous fibrillae pertaining to it, either in mammalia or birds; but this may be occasionally accomplished in fishes, and in certain muscles of insects. In these the minute detachment of the fibrous tissue may be seen to pass, and to become attached to the truncated extremity of the fibre. The fibre ends by a perfect disc, and with the whole surface of this disc the tendon is connected and continuous. The sarcolemma ceases abruptly at the circumference of the terminal disc, and here some small part of the tendinous material appears to be joined to it. Figures 42 & 43 - or 7-8 -

The Researches of Valentin and Schwann have shewn that a muscle consists, in the earliest stage, of a mass of nucleated cells, which first arrange themselves in a linear series, with more or less regu=

regularity, and then unite to constitute the elementary fibres. As this process of the union of the cells is going forward, a deposit of contractile material gradually takes place within them, commencing on the inner surface, and advancing towards the centre, till the whole is solidified. The deposition occurs in granules, which as they come into view, are seen to be disposed in the utmost order, according to the two directions already specified. These granules, or various elements, being of the same size as in the perfect muscle, the transverse stripes resulting from their apposition are of the same width as in the adult; but as they are very few in number, the fibres which they compose are of corresponding tenuity. From the very first moment of their formation, these granules are parts of a mass, and not independant of one another; for, as soon as solid matter is deposited in the cells, faint indications of a regular arrangement in granules are usually to be met with. It is common for the longitudinal lines to become well-defined before the transverse ones. When both are become strongly marked, as is always the case at birth, the nuclei of the cells, which were before visible, disappear from view, being shrouded by the dark shadows caused by the multidunious refractions of the light transmitted through the mass of granules: but they can still be shewn to exist in the perfect fibre, in all animals, and at all periods of life, by immersion in a weak acid; which,

while it swells the fibrous material of the granules, and obliterates their intervening lines, has no action on the nuclei.

These nuclei in insects are arranged, in the early condition of the fibre, as a single or double series along the axis (Fig 45 n 10); and in the adult state, they retain the same position. (Fig 42 n 1). In vertebrate animals they are scattered more irregularly, but at pretty equal distances throughout the mass in both foetal and adult conditions.

Muscles grow by an increase, not of the number, but of the bulk of their elementary fibres: there is reason to believe that the number of fibres remains through life as it was in the foetus, and that the spare or muscular build of the individual is deter=mined by the mould in which his body was originally cast.

The Unstriped Muscles, or muscles of organic life as they are also called. Fibres of these Involuntary or unstriped muscles, form the proper contractile coats of the digestive canal from the middle of the oesophagus to the external sphincter ani, of the urinary bladder, the trachea and bronchi, the ducts of glands, the gall-bladder, the vesiculae seminales, the pregnant uterus, and the arteries.

The fibres consist of flattened bands, in their most perfect form, generally of a pale colour, from $\frac{1}{3000}$ to $\frac{1}{2000}$ of an inch in diameter, very clear,

granular, and brittle, so that when they break they often have abruptly-rounded or square extremities. The texture of these fibres appears to be homogeneous. Some of them are uniform; many bear nuclei, many are marked along the middle, or more rarely along one of the edges, either by a fine, continuous dark streak, or by short, isolated dark lines, or by dark points arranged in a row or scattered; and between these three kinds of marks there are such gradations as prove that they have all the same origin from nuclei. Fibres such as these are collected in divers numbers in fasciculi, upon which the dark lines just mentioned sometimes form, by branches ~~from~~ which they give off and receive, a sort of network, and sometimes run tortuously, like the nucleus-fibres of the fibro-cellular tissue. Figure 42 or 11

None of these fibres are invested by a sarcolemma, as none have been satisfactorily detected (Todd). Their termination is also unknown. In the gizzard of the bird, the ends of the fibres are united to white fibrous tissue, thus approximating to the striped fibre.

The unstriped muscles do not possess the same Interest as the striped, their fibres do not present such a beautiful appearance

Tendons. Muscles are connected by means of lig=ments or tendons to the bones, and some muscles have their fibres longer than others. White fibrous tissue reaching from the end of a muscular fibre to some structure which is to serve as a fixed attachment for it, the bones for instance; or which it is intended to move, is called a tendon. This fibrous structure running from many contiguous fibres (as those of a whole muscle) is usually united into a single tendon. This may be either, lamellated or cordiform. according to the ar=rangement of the muscular fibres themselves.

Tendons are less bulky than muscles, first on account of symmetry. And when muscles of large size, have to be attached to a large surface, large tendons are found, spread out or diffused. But when the attachment takes place to a point, as a small point of bone, a smaller tendon in the form of a cord is employed.

If there is great bulk in the muscular fibres they are connected to the tendon in regular progression one after another, some of them being short and long, and of different lengths.

Areolar Tissue of Muscles. This tissue is more abundant in the voluntary than the involuntary muscles. To the former it gives an external investment which sends septa into the intervals between the larger and smaller packets of fibres, and thus

enables them

& move in some degree independantly of one another. It does not clothe every individual fibre from end to end except in cases where the elementary fibres are of large dimensions. Its principal use, is to furnish a nidus for the delicate vessels and nerves to traverse the interstices of the fibres and to protect them during muscular contraction.

Arteries and Veins, of muscles commonly run together, and most of the arteries are accompanied by two venae comites to within a few degrees of the capillaries. They invariably pass more or less across the direction of the fibres, divide and subdivide, first in the intervals between the larger sets, then between the smaller sets, till the ultimate twigs insinuate themselves between the fibres composing the bundles smallest and break up into their capillary terminations. In this course the vessels supply the areolar tissue, their own coats, and the attendant nerves.

The capillary plexus of the areolar membrane consists of irregular but pretty equal-sized meshes and contrasts strongly with that of the muscular tissue itself.

The proper capillaries of muscle consist of longitudinal and transverse vessels: the longitudinal always following the course of the elementary fibres, and lying in the intervals between them; the transverse being short communications placed at nearly equal distances between the longitudinal ones, and crossing nearly, or quite, transversely over or under the fibres.

The manner in which the longitudinal vessels are placed in relation to the fibres, is seen in Figure 36 or 1 represented as they are seen on a transverse section.

The diameter of the capillaries of muscle varies, like that of others, with the size of the blood particles of the animal. It is, however, only just sufficient to allow of the particles to pass. This I will show you when I come to the circulation, when I will exhibit the circulation of the blood in the web of the frogs foot.

Show Figure 17 or 12

The coats of the capillaries of muscle consist of a simple diaphanous membrane, in which a few irregular shaped cyto-blasts occur at different intervals.

The number of the capillaries of muscle correspond nearly to that of the elementary fibres.

Nerves of Muscle. As far as is at present known, all muscles in the larger animals have nerves distributed to them. The Muscles of animal life are, of all the tissues except the skin, the most copiously supplied with Nerves. These like the blood-vessels, lie on the outside of the Myolemma - or Sarcolemma of each fibre; and there influence must consequently be exerted through it. The arrangement of these nerves is shown in this figure. Show Fig 42 or 13

Their ultimate fibres or tubes cannot be said to terminate anywhere in the Muscular Substance; for after issuing from the trunks, they form a series of loops, which either return to the same trunk,

or join an adjacent one. The occasional appearance of a termination to a nervous fibril is caused by its dipping-down between the muscular fibres, to pass towards another stratum.

The non-striated muscles, however, are very sparingly supplied with nerves; and these are derived, — for the most part, if not entirely, — from the Sympathetic System, rather than from the Cerebro-spinal.

The nerves of the voluntary muscles, which are supplied from the brain, are so much more numerous than those of the Involuntary, that, according to the remark of Haller, the nerves that go to the thumb are more in quantity, than those which supply the whole substance of the liver, which as you are aware are supplied from the Sympathetic.

10

The Muscles No. 2

[illegible]

16th June 1851

To illustrate

Muscles in Contraction Todd 49. 50. 51. drawings of
Coloured drawings of Sensitive plant.
and Venus' Fly Trap.
Carpenters Manual fig 57.
Microscope to show muscular fibres

add 3 or 4 pages -

Muscles Continued.

Properties of Muscular Tissue. The great property of muscular tissue is that of shortening in a particular direction, and this property is called Contractility. The Contractility of Muscular Fibre shows itself under two forms. Irritability and Tonicity.
Its most obvious and striking manifestations are those that occur in the voluntary muscles and in the heart; which, when in action, exhibit powerful contractions alternating with relaxations. The property which is concerned in these is distinguished as Irritability. On the other hand, we find that these same muscles exhibit a tendency to a moderate and permanent contraction, which is not shown by them when they are dead, and which cannot therefore be the result of elasticity or of any simple physical property; this endowment, which seems to exist in the greatest amount in certain forms of the non-striated fibre, is called Tonicity.

That the Irritability of Muscles is a property inherent in them, and in this respect analogous to the peculiar vital endowments of any other forms of tissue, cannot be any longer disputed; — though many Physiologists have sought to show, that it is in some way derived from the nerves. Not only may an entire Muscle be made to contract, by the application of a proper stimulus, long after the division of the nervous trunks

supplying it; but even a single fibre, completely isolated from all its nervous connexions, may be seen to contract under the Microscope. Moreover, in the non-striated muscular fibre, it is often difficult to excite contractions through the nerves at all, when a stimulus directly applied to itself will immediately produce sensible and vigorous movements. The energy of the contractile power depends in great part upon the state of nutrition of the muscle; and this again is influenced by the degree in which it is exercised. Now as the Muscles of animal life are all excited to action, in the usual state of things, through the medium of their nerves, it follows that if the nerves are paralysed, the muscles will seldom or never be called into use. When disused they will receive very little nourishment, and in consequence, the muscular structure will gradually be so far impaired, as to lose its peculiar properties, — and will even in time almost totally disappear. Yet it may again be recovered, if the muscle be called into exercise.

That the Irritability of Muscular fibre belongs to itself and is not derived in any way from the nerves, is further shown by the following experiment.

If a set of muscles (as those of the leg of a Rabbit or Frog) be repeatedly thrown into action by Galvanism, until the stimulus will no longer occasion their contraction, their irritability is then said to be exhausted; by rest, however, it is recovered, — the nutritive processes making good the loss previously suffered.

Dr John Reid has shown, that this recovery may take place even after the division of all the nerves supplying the limb; provided its nutrition is not interfered with. He has further shown, that if the nerves of a limb be divided, the loss or retention of Contractility depends upon the degree of exercise to which the muscles are subjected, and consequently upon the nutrition they receive.

The muscles of the hind-leg of a Rabbit, whose sciatic nerve had been divided, were found to lose their contractility almost completely in the course of seven weeks. They were much smaller, paler, & softer, than the corresponding muscles of the opposite leg; and they scarcely weighed more than half as much as the latter.

If both nerves in a frog are cut, and one of the limbs exercised by a weak galvanic battery, and the other allowed to rest, the muscles of the exercised limb will retain their original size & firmness, and will contract vigorously, whilst those of the other will shrink to half their size.

By these and other facts, it may be regarded as completely proved, that the Irritability of Muscles is a vital endowment, belonging to them in virtue of their peculiar structure; — that so long as this structure is maintained in its normal condition by the nutritive processes, so long is the property capable of being manifested; — but that any cause which interferes with the nutrition of a muscle, impairs or destroys its ~~vitality~~ Irritability.

All Muscular Fibre, which has not lost its Contractility, may be made to contract by a stimulus applied directly to itself; and this stimulus may be of three kinds 1 Mechanical 2 Chemical 3 Vital

Of the First the simplest is the contact of any solid substance; thus we may excite muscular contractions by simply touching the fibre, — just as we cause contraction in the tissue of the Dionaea or Sensitive Plant.

(show drawings of & explain it)

Of the Second - Most substances of strong chemical action such as acids and alkalies, metallic salts, &c will call forth the contractility of muscular fibre, when applied to it. The same result is produced by the Third or Vital Stimuli - as heat, cold, electricity, - the last named agent being the most powerful of all. The effect of the application of any of these stimuli varies considerably, according to the kind of Muscle on which it is exerted. Some act only on particular muscles as in the case of certain Purgatives and Emetics.

If we irritate a portion of a muscle composed of striated fibre (any one of the voluntary muscles for example) the fasciculus of fibres which is touched will immediately contract, and that one only; and the contracted fasciculus will soon relax, without communicating its movement to any other.

If we irritate a portion of non-striated fibre, however, as that of the Alimentary Canal, the fasciculus which is stimulated will contract less suddenly but ultimately to a greater amount; its relaxation

will be less speedy; and before it takes place, other fasciculi in the neighbourhood begin to contract; their contraction propagates itself to others; and so on. In this manner, successive contractions and relaxations may be produced through a considerable part of the canal, by a single prick with a scalpel. Again in the muscular structure of the Bladder and Uterus, powerful contractions are excited by irritation, and these produce a great degree of shortening. In the Heart the muscular structure of a large part of the organ is thrown into rapid and energetic contraction, by a stimulus applied at any one point; and this contraction is speedily followed by relaxation. And in the fibrous tissue of the middle coat of the Arteries, the contraction takes place rather after the manner of that of the bladder and uterus, and a prolonged application of the stimulus is often necessary to produce the effect; but when the contraction commences, it produces a considerable degree of shortening, which takes place in other fasciculi than those directly irritated, and does not speedily give way to relaxation.

On the other hand, when the stimuli which excite muscular contraction are applied to the nerve, which supplies a voluntary muscle composed of striated fibre, they produce a simultaneous contraction in the whole muscle; the effect of the stimulus being at once exerted upon every part of it. The nerves of the striated fibre are all derived at once from the brain or spinal cord. The ordinary actions of the non-striated fibre, on the contrary, are executed in respondance to stimuli applied directly to themselves.

the nerves of the non-striated fibre are chiefly those belonging to the Sympathetic system.

When a Muscle is thrown into Contraction, its bulk does not appear to be at all affected. Its extremities approach, so that it is shortened in the direction of its fibres; but its diameter enlarges in the same proportion. In other words, in becoming shorter & thicker it gains in breadth what it loses in length.

It was formerly supposed that the ultimate fibres, in the act of contraction, threw themselves into zig-zag folds; but this is now well ascertained not to be the case. The fibre, like the entire muscle, preserves its straight direction in shortening, and increases in diameter. The fibrillae themselves, exhibit an evident change, in regard to the distances of their successive light and dark portions; and the fibre, which is made up of these, exhibits, in its Contracted state, a very close approximation of the transverse striae, to such an extent that they become 2, 3, or even 4, times as numerous in a given length, as they are in a similar length of a non-contracted fibre.

{ Figures 4 figs 50 & 51. [illegible]
{ showing different forms of contraction -

Muscular Sound - When the Ear is applied to a muscle in vigorous action, an exceedingly rapid faint silvery vibration is heard, which when well marked has a metallic sound. Dr Wollaston compares it to the distant rumbling of Carriage wheels. It appears to be occasioned by the Constant movement

of the fibres upon one another.

Increased Temperature. M. M. Becquerel and Breschet have shown, that the temperature of a muscle rises, when it is thrown into energetic contraction. The increase is ordinarily but about 1° Fahr., but sometimes increases 2° if the muscle be kept in action for sometime. Two causes are assigned for this. One the chemical changes which take place in the muscles, as a necessary condition of the production of its force; the other, the result of friction taking place between different parts, during the constant interchange of their actions. Both perhaps concur in producing it.

Conditions requisite for manifestation of Muscular Irritability. Nutrition, and circulation of arterial blood through the substance of the muscle.

The length of time during which the contractility remains, after the circulation has ceased, has been shown by Dr M. Hall to vary inversely to the activity of the respiration of the animal. thus in cold blooded animals, the standard of whose respiration is low, the contractility remains many hours after death, even in the voluntary muscles and the muscles of organic life retain it with great tenacity. Thus the heart of a Frog will go on pulsating for many hours after its removal from the body; and the heart of a Sturgeon, which had been inflated with air and hung up to dry, has been seen to continue beating,

until the auricle had become absolutely so dry, as to rustle during its movements. An exceedingly feeble galvanic current is sufficient to excite the muscles of these animals to contraction; so that Matteucci, in his experiments upon Animal Electricity, has been accustomed to use the prepared hind-leg of a Frog as the best indicator of the passage of an electric current.

Among warm-blooded animals, the same rule holds good, in regard to the inverse proportion of the duration of irritability, and the amount of respiration; for the muscles of Birds lose this property at an earlier period after the cessation of the circulation, than do those of Mammals.

That the circulation of arterial or oxygenated blood through the muscles, is the essential condition of the continuance of their irritability, appears from this, — that after the general death of the system, and even after the removal of the brain and spinal cord, the muscles will preserve their irritability, and the action of the heart itself will continue for a long time, provided that the circulation be kept up through the lungs by artificial respiration, on the principles to be explained hereafter. But if, whilst the general circulation continues, the circulation through a particular muscular part be interrupted, that organ will lose its contractility earlier than usual. Thus it has been shown by Mr Erichsen, that if the coronary arteries (supplying the substance of the heart) be tied in a dog or a rabbit, after the animal

has been pithed, and the circulation is being maintained by artificial respiration, the pulsation of the heart will only go on for about 23 minutes after the ligature has been applied, or about 33 minutes after the death of the animal; instead of continuing for 90 minutes, which it will do under other circumstances.

Further, if blood charged with carbonic acid, instead of with oxygen, circulate through the muscles, their irritability is speedily impaired, and is even destroyed. On the other hand, when animals have been made to respire oxygen, and their blood has been consequently highly arterialised, the contractility of their muscles is retained for a longer time than usual.

The Muscles, as we have seen, are largely supplied with blood; and the flow of blood into them increases with the use made of them. The demand for nutrition is obviously augmented, in proportion to the activity of the exercise of the Muscular system; for the slightest observation suffices to show, that a much smaller amount of nourishment is sufficient to sustain the body in its normal condition, when the muscular system is not actively exercised, than when it is in energetic operation. The quantity which is ample for an individual leading an inactive life, is far too little for the same person, in the full exercise of his muscular powers. Again, there is evidence derived from observation of the relative amount of the solid

matters excreted from the body under different circum=stances, that a waste or distintegration of the muscular tissue takes place, whenever it is actively employed; and this in a degree strictly proportional to the amount of force which it is called upon to exercise. In fact, it would appear that this waste is a necessary con=sequence of the exercise of the muscle; — every act of contraction involving the death and decomposition of a certain amount of tissue. And as the presence of oxygen is always necessary for the decomposition of organic substances, so do we find that the penetration of the muscular tissue by oxygenated blood is essential to the manifestation of its contractile power.

The rest of muscles is essential to the recovery of their powers; and this recovery is due to the nutritive operations, which then take place un=checked, and which repair the losses previously sustained.

The more a muscle is exercised, the more vigorous and bulky does it become. This is equally the case, whether the exercise of the muscle be voluntary or not. We see examples of it in the arms of the smith and in the legs of the opera-dancer.

Tonicity which is the other form of Contractility, manifests itself in the retraction which takes place in the ends of a living muscle, when it is divided; the retraction being permanent, and greater than that of a dead muscle. It also

shows itself in the permanent flexure of joints, when, by paralysis of the extensors, the tonic contraction of the flexors is not antagonised.

The Tonicity is much greater, relatively to the amount of irritability, in the non-striated, than in the striated fibre; and it is particularly remarkable in the fibrous coat of the arteries, in which it is difficult to procure any decided indication of irritability by the application of stimuli. It is by the tonicity of the walls of the arteries, that they are kept in a state of constant moderate contraction upon their contents; and that, when they are emptied, they contract until the tube is nearly obliterated. If this amount be too great (as sometimes happens) the artery approaches the condition of a rigid tube, which is unfavourable to the regularity of the flow of blood through it, though the rate is increased. On the other hand, if it be unduly diminished, the circulation is retarded, by the tendency of the arterial walls to yield too much to the pulse-wave.

This property is very greatly affected by temperature; being diminished by warmth, and increased by cold. Thus when an artery is exposed to the air for sometime, the lowering of its temperature occasions its contraction to such an extent, that its tube may be almost obliterated.

The Rigor Mortis, or death stiffening of the muscles, is probably to be regarded as a manifestation of this property, occurring after all the Irritability of

the muscles has departed, but before any putrefactive change has commenced. This phenomenon is rarely absent; although it may be so slight, and may last for so short a time, as to escape notice or observation. The period which elapses before its commencement is as variable as its duration; and both seem to be dependant upon the vital condition of the system at the time of death.

The commencement of the rigidity usually takes place within seven hours after death; but twenty or even thirty hours may elapse before it shows itself. Its general duration is from twenty four to thirty-six hours; but it may pass off much more rapidly, or it may be prolonged for several days. It affects all the muscles composed of the striated fibre with nearly the same intensity, except that the flexors usually contract more strongly than the extensors.

As soon as the Rigor Mortis departs, the muscles pass into a state of decomposition; in fact, it is by the commencement of decomposition, that the cessation of this vital property is occasioned. Thus we may regard the Rigor Mortis as the last act of the Muscular Contractility; and in this respect it corresponds with the coagulation of the blood, which also is the closing act of its life, when it is drawn from the living body, or has ceased to circulate.

In ~~the~~ my first lecture on Muscles, I stated that the muscular tissue was chemically composed of fibrine. It and the fibrine of the blood may be said to be identical, and there seems no doubt that muscle is formed by the direct deposition in a solid form of the fluid fibrine of the blood. In birds, the blood, i.e. the fibrine, coagulates, or assumes the solid form very quickly when withdrawn from the vessels, in mammalia less so, and in reptiles and fishes very tardily. A fatal stroke of lightning which instantaneously destroys contractility in the muscles, prevents also the coagulation of the blood.

Colour of Muscles. In man and the higher animals, the muscles possess a reddish-brown colour, but this is not essential, as by washing, &c they may be rendered white. It was thought to depend on the quantity of blood, but Bichat showed that it was not the case. In birds the muscles are white, in fowl tribe particularly, whilst they are darker in the duck tribe -

If we macerate muscle we obtain in the fluid a principle of a brown colour, an acid taste, and aromatic odour, soluble both in water and alcohol, it is called Osmazone. It is it that gives the peculiar smell to roast beef, and its presence is supposed to give the red colour to muscle.

Muscle is Composed of Hydrogen -
Nitrogen -
Carbon -

It is converted into Adipocere, by diluted Nitric acid, maceration in water, & other methods -

11

The Arteries, Veins and Capillaries.

C. D. Gibb MD

18th June 1857

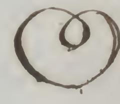
To illustrate

Page 2 of Lecture. Queains & other plates -
drawing of Capillaries.
Hassals plates
Boerhaaves Physiology plate 14. Veins & Valves
do 21. Vasa Vasorum

add 2 pages more

__The Arteries__. There are __two__ great arterial trunks, the Aorta and the Pulmonary artery, the former corresponding to the __greater or systemic circulation__ and the latter to the __lesser or pulmonic circulation__.

We find that arteries are usually situated in parts where they are protected from external injuries. as the Femoral - Iliac - Aorta.



In some places they are protected by layers of strong fascia, as in the palmar and plantar arteries - the intercostals - and in the situations where they would be subject to great risks of injury, they are protected by bony canals, as in the __Lion__ where the artery of the foreleg passes through a hole in the bone; and the __aorta of fishes__ is continued on to the tail through a hole in one of the vertebra. In the __horse__ the arteries of the foot pass through a canal in the coffin bone.

As a general rule, arteries take a __direct course__ except under the following circumstances.
__1st__ For the purpose of allowing the extension of parts, without laceration of the vessels, and the dilatation of hollow organs; as the heart. __2nd__ They present a greater extent of surface for the origin of branches. __3rd__ To diminish the impetus of the Blood. __4th__ For performance ✕

__Anastomosis__. Explain the meaning of this term -
__Three__ kinds of Anastomosis -

✕ of particular functions, as hatching of eggs, the rete-mirabile, new formation of vessels for producing heat.

1st In the form of an arch - as in the case of the gastro-epiploica sinistra and the gastro-epiploica dextra - to meet at the convex margin of the stomach. In this form of anastomosis, the blood coming in opposite directions is retarded and driven from the larger into the smaller trunks.

2nd Anastomosis by Convergence - as in the meeting of the two vertebral arteries - to form the Basilar.

3rd Anastomosis by transverse Communication - as in the anterior arteries of the cerebrum.

Show Quain's Plates & others to illustrate

The Rete Mirabile of Galen - is a net-work of vessels in the basis of the brain in many long-necked herbivorous quadrupeds, formed from the branches of the internal carotid as they enter the skull. This is to moderate the rapidity of the circulation on entering the cranium.

Hunter discovered a remarkable plexus in the intercostal arteries of the whale, everywhere lining the walls of the thorax. This forms a receptacle for storing arterial blood during the submersion of the animal. ✻

For the same reason the Seal has numerous venous dilatations around the Heart, as described by Mr Houston.

Plexus of Incubation - explain its nature and uses.

The Arterial plexus in the limbs of the Sloth, has been described by Mr Wardroff and Sir A Carlisle - It consists in the sudden division of the axillary & iliac arteries, just before entering the limbs, into numerous

✻ which comes up every 20 m to breathe.

S# In diving birds, there is a peculiar division of veins to allow of want of respiration. Veins are very large and peculiar in Northern Diver or Loon, the Vena Cava Inferior being the same size as in the human subject

small channels, which again unite into one trunk before the arteries of the member are given off.

Structure of Arteries. Arteries have 3 Coats.

1st External. - a pale firm membrane, with fibres closely interwoven, and crossing the vessel's axis obliquely, - closely applied to the middle coat - its external surface is continuous with the surrounding cellular membrane, thus constituting a loose sheath for the Vessel. It is the external Coat which enables the artery to resist extension in the longitudinal direction.

The internal coat - is composed of a thin, transparent very delicate membrane, in many respects closely resembling a serous membrane, and by many supposed to be identical with these membranes. It is continuous with the lining membrane of the heart. We cannot trace either vessels or nerves into it. It is extremely brittle and inelastic, in both of which it differs from genuine serous membranes. In the large arteries it is thrown into longitudinal folds - in the popliteal and brachial arteries it is thrown into transverse folds, corresponding to the angle of flexure.

Middle Coat is composed of yellow tissue; the same as that found in the ligamentum nuchae. It is composed of fibres, which take a course transversely around the artery. Each of these fibres nearly surrounds the artery, but does not do so

completely. These fibres are divided into two layers, in the under one it is supposed the elasticity resides, whilst to the outer one, the power of muscular contraction has been accorded by those who believe in the muscularity of this coat of the artery.

Arguments for the Muscularity of arteries.

1st Some lower animals have no hearts - merely pulsating arteries, but their aortic enlargement answers the same purpose.

2nd The Acephalous Foetuses, have frequently no hearts, but they have a rudimentary heart.

3rd The circulation in Fishes. In these the whole capillary system of the lungs is interposed between the heart and aorta. Heart contains only 1 Auricle & 1 Ventricle.

Hunters experiments to prove muscularity of arteries.

1st He bled a dog to death by cutting across the posterior tibial artery. He found that the stream of blood gradually diminished according as the artery contracted, and at last it completely ceased.

2d Experiment, He bled a horse to death, and on examination he found the aorta contracted. He cut out a portion of this vessel and having slit it up he stretched it out and then allowed to contract again, when he found that its contraction stopped midway between the point to which it had been contracted before he stretched it, and the point

to which it was stretched - from these two experiments he concluded that the middle coat of the artery was muscular, and that it was owing to this property that the vessel was enabled to contract to such an extent originally. The Objections urged to these, were

1st Vital contractility is not a proof of Muscularity.

2nd If India Rubber were stretched in the same manner it would not regain the exact size it possessed before the stretching was commenced..

Although many Physiologists have denied, that the Arteries possess real muscular contractility in any degree, there is now no longer any doubt upon the subject; since numerous experimenters have succeeded in producing distinct contraction of their walls, by the application of those stimuli which act upon muscular fibre in general.

I look upon the terms, Vital Contractility and Muscular Contractility as synonymous.

Again it has been urged that the Bulbus Arteriosus of fishes and Amphibia, may be seen to contract. Müller has seen this, but he states that this is in point of fact a heart, and cannot be considered as part of the arterial system, strictly speaking.

Again - it has been urged, that in corresponding limbs, the pulse is unequal -

The same thing has been observed in Paralysis and in inflammation.

Hodgkin has observed that, the arterial fibres when examined with the Microscope, do not present the striae so characteristic of muscle.

Bichat objected to the doctrine of the muscularity of arteries because there is a tendinous ring separating the ventricles from the arteries, as if to separate their structures one from another, but he forgot that the ventricles & auricles, whose muscularity is undoubted, are separated by rings of precisely the same nature — therefore his objection falls to the ground.

Bichat has also shown that an ossified state of the arteries, does not interrupt the circulation, but this is the very Pathological change which the advocates for the muscularity of arteries consider as most strong on their side - For they say, mortification takes place when the muscularity is destroyed by the deposition of bony matter in the coats of the vessel.

This long unsettled question, has at last been settled, and for ever. The arguments of those in favour of the non-muscularity of arteries, are completely overthrown. The Microscope in the hands of Mr Quekett at the College of Surgeons in London, has revealed the truth; which has been published in the Lancet of this year, in a lecture delivered by Mr Guthrie.

The ancient 3 coats which I have described to you, are each divided into 2.

The inner or old serous coat, is shown to be separable into two: the epithelial, 1 and the fenestrated 2.

the middle coat is also separated into two; the inner or muscular 3, and the outer, or elastic 4.

The outer coat, is divisible also into two layers, the inner 5, and the outer 6. number 5 being composed more of elastic fibres; number 6 more of areolar fibres; by which tissue, in a less condensed state, the arteries of the extremities are attached to their sheaths. Such may be considered to be the general composition of a large artery, each particular structure remaining to be examined.

You will be astonished when I tell you, that all that has been written for and against the muscularity of arteries, together with numberless experiments would fill several volumes.

Examination of the different layers —

1. The epithelial layer of the inner coat, is of the tesselated or pavement kind, composed of one or more layers of nucleated cells, of a flat, oval, round, hexagonal or polygonal form and about two of an inch in diameter. It is very similar to the epithelium of serous membranes.

2. The fenestrated or perforated layer, forms the second layer of the internal coat. It can be peeled off in small pieces only, and shows a series of fibres running in almost parallel lines upon a comparatively structureless membrane, resembling the inner layer of the cornea. They frequently bifurcate and join again, so that an oval space, resembling a hole is perceived. This is not always a hole or perforation, as it is generally described to be, as may be seen and proved by the fact of the supposed opening being sometimes filled up by small bodies,

like nuclei, as if the oval space were occupied by a cell.
These 2 layers compose the ancient inner coat of an artery, and are frequently the seat of disease.

3. The Muscular or inner Layer of the Middle Coat, is composed of muscular fibres of the organic or involuntary kind, consisting of more or less flattened bands, the fibres of which are soft, and marked with minute granules, sometimes exhibiting traces of nuclei. These purely muscular fibres are most abundant next to the inner coat of the artery and diminish in number as they approach the outer layer, their place being occupied by firmer and more elastic fibres of a yellow colour.

The involuntary ~~muscular of an~~ muscular fibres of an artery are rather smaller than those found in the intestines, bladder, and uterus.

4. The Elastic or outer layer of the Middle Coat, is formed of strong elastic fibres, difficult of separation and when torn across, have curled extremities (Fig) differing only in size from those found in the ligaments of the spine and in the ligamentum nuchae of Quadrupeds. This is yellow elastic tissue.

5, 6. The two layers forming the External Coat, are composed of the yellow elastic fibres just noticed and another set of fibres, white in colour, & inelastic, arranged in various directions; the inner layer predominating in yellow elastic, the outer layer in white inelastic fibres, and constituting a firm investment to all the other layers of which the artery is composed.

{ See Lancet Vol 1, 1857 pages 173 et seq-
for details and drawings —

Vasa Vasorum. The arteries are supplied with blood by vessels of small size, which are not furnished by the artery they are destined to supply, but from neighbouring vessels. They are called Vasa-vasorum. They are arranged precisely in the same manner as that of [illegible] tissue. A few of these vessels penetrate as far as the middle or muscular coat, but do not reach the inner which has no vessels.

Nerves. Branches from the sympathetic, running into the walls, and forming a network around the vessels, supply them with nervous influence; and also through their connexion by ganglions with the organs they supply with blood. Arteritis is a very painful disease.

Absorbents form a network with the nerves —

Form of Arteries. Bigatts observations — {all assume a conical form, a base & an apex —

1 Cone with base to the Heart
2 Truncated Cones opposed at their summit.
3 Cone with summit to the Heart.
4 Cylindrical
5 Cones with bases opposed.

(Flood p. 51 introd.) —

The Pulse is due to an increase in the dimensions of the arterial tube both in length and breadth, with each additional ingress of blood; the increase in length is the more considerable of the two effects, and causes the artery to be somewhat lifted from its seat. During the intervals a quantity of blood corresponding to that which had entered, escapes by the further extremity of the tube; and thus the artery is enabled to contract to its previous dimensions, and to return to its bed. Pulse has been compared to a wave, commencing at the heart,

Tonicity of arteries - what? 1 If a ligature be placed upon an artery; the latter contracts above the ligature. 2. If a portion of artery be included between 2 ligatures and be then punctured the contained blood is ejected and the artery contracts greatly. 3 Exposure of arteries to cold air will induce contraction. 4 By contraction of arteries nature arrests haemorrhage

they also contract after death, expelling all the blood! Haemorrhage spontaneously ceases from a wound on the field of battle.

and travelling onwards through the arterial system.
Tonicity. arteries are found empty after death, due to this property.
Tonicity? What. Ligature. Cold. Haemorrhage.

Elasticity of an artery.

Veins, are more numerous than the arteries, and have an arborescent appearance. They have a greater calibre than arteries, which correspond with them, and the blood is transmitted with less rapidity through them.
They are much thinner in structure than the arteries, so that when emptied of their blood they become flattened and collapsed.
Structure. Veins like arteries are composed of three coats, external or cellulo-fibrous, middle or fibrous, and internal or serous. They possess no complete elastic coat.
The external coat, is firm and strong, and resembles that of the arteries, already described. It is a condensed cellular tissue. It is deficient and its place supplied by other parts in other situations, as in the bones, the sinuses, and the corpus cavernosum penis.
The middle coat, consists of two layers, an outer layer of contractile fibrous tissue disposed in a circular direction around the vessel, and an inner layer of organic muscular fibres arranged longitudinally.

solitary valve, pair of valves. . In <u>varicose veins</u> the valves are diseased, which comes on from long standing, they then become tortuous and twisted.

This latter resembles the inner layer of the middle coat of arteries but is somewhat thicker, and is not unfrequently hypertrophied. The internal coat, as in arteries, consists of a striated or fenestrated layer, and a layer of epithelium. It is continuous with the internal coat of arteries through the medium of the lining membrane of the heart on one hand, and through the capillary vessels on the other.

The differences in structure, therefore between arteries and veins relate to the difference of thickness of their component layers, and to the absence of the elastic coat in the veins. Another difference occurs in the presence of valves in the veins.

Veins are supplied with, bloodvessels, absorbents & nerves. The nerves do not form plexuses around them, as they do round arteries except in the system of the Vena porta.

Valves - are duplications of the lining membrane. Some of deep seated veins are entirely devoid of them - None in the cerebral or pulmonary veins, nor in superior or inferior Cava, internal jugular vein, vena porta. They are more numerous in those in which the blood moves against gravity. Valves are ~~more fre~~ sometimes solitary as in the small veins, but more frequently they occur in pairs. # The valves are semilunar, their free margins are turned towards the heart, so as to stop any movement of blood backwards in the veins.

Properties of Veins. they possess no inconsiderable amount of Elasticity; and a certain degree of Muscular Contractility. They are capable of great extension in the transverse direction, & slightly so in the longitudinal.

the whole capacity of the Veins is at least twice & nearly three times that of the arteries, & the motion of the blood is slower. Veins possess, Sensibility as shown in Inflammation.

Causes of Venous Pulsation. Regurgitation of the blood from the ventricle into the auricle, and thence into the venae cavae, during the ventricular systole, and the pulsation thus occasioned is synchronous with that of the arteries. This regurgitation may take place, not from any disease of the valves on the right side of the heart, but simply from over distension of its cavities, resulting from any obstruction to the circulation through the lungs.

The Respiratory movements, also produce pulsation in the veins of the neck and shoulders in thin persons, and especially those suffering from Pulmonary diseases.

(See Carpenter's Manual p 351) –

Other Causes of – 1st – Sorbent power of heart – Barry
2nd – Elasticity of lungs – Carson –
3 – A Vacuum in the Chest –
aided by Muscular action as in
& by Valves –

Haemorrhage can be easily arrested in veins –

Capillaries are the connecting vessels between the arteries and veins. Some admit 3 and others not more than one globule at a time. The capillaries may be seen in minutely injected preparations, by the aid of the microscope, and in different textures, such as the web of the Frogs foot, tail of tadpole and young fish;

mesentery of animals, wings of the bat, &c.

Size varies from $\frac{1}{1000}$ to $\frac{1}{4500}$ or even $\frac{1}{5000}$ of an inch. No other tubes in the body are so minute as the capillary vessels. The diameter of the Biliary ducts of the liver, or of the tubuli uriniferi is several times greater than that of the capillaries.

They present a net-work appearance. Show Figure. The network is closest and most compact in the lungs and in the Choroid membrane of the eye. It is also very close in the mucous membrane of stomach, liver and kidneys, and in the cutis vera.

How do arteries terminate? In open mouths? The microscope has shown that the capillaries are minute tubes leading from the arteries to the veins and that no other vessels are to be found leading from the termination of the arteries; so that there are no vessels terminating by open mouths.

It must also be borne in mind that the capillaries do not in reality constitute a separate order of vessels, they differ in no particular except minuteness from the small arteries which terminate in them. Many supposed (as Wedemeyer) that the Capillaries were mere canals, without walls, but these latter have been satisfactorily demonstrated by the microscope, and that they are composed of fibrous structure analogous to the muscular.

Haller thought that arteries opened in five different ways 1st by opening on the surface of membranes.

2nd in lymphatics – 3 in secreting canals; 4th in fat; and lastly in veins. this hypothesis is quite confounded.

Serous Vessels. Many suppose that there are vessels too minute to carry red globules, which give passage to the serous portion of the blood. Such vessels are supposed to exist in the cornea, the capsule of the crystalline lens and the vitreous body. These vessels have never been demonstrated even by the aid of the microscope.

Objection to Serous Vessels. 1st If they did exist would they not be blocked up at their outset by the red globules, getting jammed up against their orifices?

2d. Because we do not see red vessels, that is no proof that vessels carrying red blood do not exist, because we fail to detect the red colour even in the capillaries carrying red globules; it requires an accumulation of these to give a red colour.

Red vessels are however seen in ulcers of the cornea, in the cornea of young calves. The Posterior Capsule of the lens has red vessels, supplied by the small artery that passes through the hyaloid membrane.

Circulation as seen by the aid of the Microscope.

Equable – sometimes stronger – this is owing to the arterial pulse. When the animal becomes faint, the circulation only advances with the pulse, but if the animal becomes more debilitated, the globules are seen occasionally to recede.

The equable motion of the Blood in the capillaries is explained by the elasticity of the arteries, which keep up a continuous current in these vessels - which current is occasionally accelerated during the pulsation in the arteries.

According to Muller the motion of the Blood in the capillaries is wholly dependant on the Hearts action.

12

Blood

J. D. Gibb M.D.

20th June 1887

To illustrate

drawings of globules
use Micros to show human & frogs blood.
drawing of colourless cells.

with the use of the Mic: this lecture is of the right length. and writing the analysis of the blood - add another analysis, more minute with proportions -

The Blood. The blood constitutes from 8 to 20 lbs in the weight of the body. It is divided into two portions, a red portion and a colourless: the former is called the red globules, the latter the Liquor Sanguinis, the Lymph, or Fibrine; this is distinct from the Serum.

These portions separate spontaneously from one another soon after blood is taken from the body and allowed to remain at rest: the red particles sink - the lymph forms a firm crust, & the serum floats on the top of all. Spec: grav: of Human Blood 1.0527 to 1.057. Slightly saltish taste, weak alkaline reaction, and peculiar odour. This last quality differs in different animals, and is said to be stronger in the male.

Blood Coagulates within 2 & 10 minutes after re=moval from the Body, except in the Human subject; it then requires from 3 to 10. The Rabbit requires 2 min.

Serum - Spe: grav: 1.027 to 1.029. It has a saltish taste and a weak alkaline reaction. It contains some organic matters - (principally Albumen) in solution.

If the red coagulum be washed, the red globules are got rid of, and then we obtain pure fibrine.

Coagulation of Blood is prevented by the addition of Caustic Soda, and it is retarded by the addition of Sulphate of Soda, Nitrate of Potash, Carb of Soda, & Carb of Potash -

Fontana states that the poison of the Viper and of the Tucuna, 1 part added to 20 of Blood prevents coagulation, whilst the poison of the Viper, causes coagulation when brot into contact with the blood within the body.

The Blood does not coagulate in those killed by lightning, or in animals killed by strong electric shocks - nor does it coagulate in those who have been poisoned by Prussic acid, or by violent blows on the Epigastrium - nor ~~does it coagulate~~ in animals hunted to death - It also remains fluid for a long time in those who die of asphyxia. Except under the above circumstances the Blood will coagulate, whether in rest or motion, in vacuo or in close vessels, hermetically sealed - in various gases which do not Constitute part of the Atmosphere.

Cause of Coagulation - the Blood is removed from contact with living particles - viz in the vessels - for when extravasated in cellular membrane it coagulates.

It is however necessary that in addition to being in contact with the living body, that it should be in motion, for when included between two ligatures in an artery it coagulates.

Coagulation takes place quickly after the Brain and Spinal marrow are destroyed - but Mayer wished to extend this to cases in which the nervus Vagus was divided, but Müller's experiments do not confirm his views.

Blood extracted from the Vessels coagulates more strongly in proportion to the exhausted condition of the system.

Microscopic Characters of the blood -

Best mode of examining red particles - should not be diluted with water, as this changes their shape, they absorb the water and assume ~~a~~ a spherical outline.

1st from flat to be spherical, and from being elliptical to be round. Add either serum, or salt and water, or a mixture of 1 part of sugar to 99 of water.
Müller adds to the serum of the Frog, a small quantity of the blood of that animal.

The globules are always flattened, no matter whether they be elliptical or round.

They are circular discs in man & the Mammalia } Show
In Birds, reptiles, Amphibia & fishes, they are } Fig.
elliptical. In all they are flattened - but particularly so in the latter animals -

The observations of Gulliver & Wharton Jones go to prove that the blood discs of the Mammalia do not possess nuclei. - they state that the appearance is owing to the albumen contained in the discs being coagulated by the acetic acid. Carpenter agrees with them.
Central spot - Describe it - this assumes the shape of the disc - in the circular it is circular, & in the Elliptical it is elliptical. The disc is the haematozine, the cell the globuline.

Müller takes some pains to ~~[illegible]~~ prove that he has seen the central spot in the blood globules, and says he has seen them with an excellent (Fraunhofer) microscope !!

The size of the red particles in man is uniform - some are a little larger than others, but none of them have twice the diameter of others. The small ones seem to be in the progress of formation - difference between them and milk.

Red particles of the Amphibia are the largest of all, Siren frog and proteus. The Blood of Frogs has red globules larger than those of fishes or of the Mammalia, and they are at least 4 times the size of those of man_ The red globules of the goat are the smallest, and those of the Salamander the largest that have yet been described.

I have taken the average between the measurements given by nine observers, and find that the size of the red particles of the Blood, amounts to 4237. of an English Inch_!

Lymph globules of the Blood_ These have been observed by Müller in blood taken from a Frog's heart_ they resemble the colourless blood globules; they each possess a central nucleus_ Müller says these are identical with the colourless globules of the blood_ in the Frog.

× For information concerning the effects of different Agents upon the red globules see Müller p. 119.

The size and form of the red globules are the same in the arterial and venous blood: this was stated otherwise by Kaltenbrunner_

Liquor Sanguinis_ The Fibrine_

Müller shows that fibrine is held in solution in the Blood. This was opposed by Home, Prevost & Dumas, who asserted that it was contained in a solid form in the blood discs. Müller filters through thin white paper

the blood of one Frog:– this arrests the red particles, and allows the serum and fibrin to pass through, the latter being dissolved in the former. In a few minutes coagulation takes place – the coagulum gets firm, contracts and assumes a whitish colour, being in all these particulars identical with the fibrine of human Blood.
Muller & Hewson also prove this – by adding a strong solution of Caustic Potash to blood, which retards coagulation and allows the red particles to subside – a coagulum forms, the lower part red (from the globules) and the upper part white.

In 100 parts of Bullocks blood, there were 16.248 parts of dry Crassamentum and 0.496 parts of fibrine.
Causes of the Buffy Coat – This appears to be caused by the slowness with which inflammatory blood coagulates, which allows the red particles to subside, and separate themselves from the fibrine. Müller has confirmed this explanation, by causing a retardation of coagulation, and then the buffy coat was produced.
2nd. Another cause, may be found in the fact that inflammatory blood contains much more fibrine than healthy blood.
Serum. This is the fluid, which remains after separation of the fibrine – it possesses a slightly yellowish colour and saltish taste; its spec: grav: is 1.027 to 1.029. It coagulates at 158° & 169° Fahr, which depends on its containing a quantity of albumen it also contains a free alkali, – soda (potash according to Berzelius). The serum of Human

Blood contains 1/10 part of solid ingredients, of which albumen is the most important.

Chemical Analysis of the Blood.

Fibrine Albumen Salts	In solution, forming Liquor Sanguinis	In the circulating Blood.
Red Corpuscles -	Suspended in Liquor Sanguinis	

Fibrine Red Corpuscles	Crassamentum or Clot.	In Coagulated Blood
Albumen Salts	Remaining in solution forming serum	

The solid matter of the blood contains:-

various Fatty substances - some containing ordinary Fat - another phosphorus - another the properties of Cholesterine, the fatty matter of the bile -

Besides there are substances known as Extractive.

The Saline Constituents - amount to 6 & 7 parts in 1000 -

Chlorides of Sodium & Potassium -
Tribasic Phosphate of Soda
Phosphates of Lime and Magnesia
Sulphate of Soda
Little Phosphate and Oxide of Iron.

The chief parts of these are dissolved in the serum -
The iron is contained, chiefly in the red corpuscles -
The serum is alkaline and has been supposed to be due to the presence of alkaline Carbonates -
The presence of Lactates of potash & soda has been usually asserted.

Changes which take place in the blood during its passage through the body. The Blood in its passage through the capillaries loses its arterial colour and acquires a venous hue. Whatever be the exact renovating process it performs on the structures as it passes, it loses some of its properties and being then unfit for the further nourishment of the body, it is returned by the veins to the heart, whence it is propelled through the lungs. In the lungs the venous blood gets rid of its carbon and loses its dark colour, and once more assumes the bright arterial hue. It is then returned to the heart and from it, it passes onwards ~~to the~~ through the arteries from the larger to the smaller branches down to the Capillaries where it again performs the same function and is again subjected to the same chemical change, as has just now, been alluded to —

If from any cause the lung should not get rid of its carbon in the lungs, asphyxia & death are produced, in consequence of impure blood being sent to the Brain. Brain requires the stimulus of arterial blood.

If all the arteries of a limb be tied, the power of motion is lost. Sir. A. Cooper produced death instantaneously in a rabbit by stopping the current through the vertebrals and the Carotids — the influence of the blood, on the vitality of organs, was shown by Humboldt in the Heart of a Frog which began to pulsate on being immersed in Blood; and Valentin and Purkinje observed that the Ciliae on Mucous membrane resumed their movements on being brought in Contact with blood —

The vivifying power of blood resides in the red particles for if an animal be bled to syncope, and we infuse serum at the Temper of 68° Fahr, it will not restore the animal, but if we inject red blood, the animal quickly recovers. It has also been stated by Prevost and Dumas, and by Deiffenbach and Bischoff that recovery will take place even if the blood be deprived of its fibrine, so that we must conclude that recovery depends in those cases upon the introduction of the red particles.

Is the Blood alive?

Schultz has described a movement in the blood - as seen under the microscope; - this he thinks depends upon an oscillatory movement in the fluid particles: but Purkinje, Muller and others have shown that this supposed movement does ~~xxx~~ in reality depend upon the refraction of light: for it appears that he has examined the blood when exposed to the direct rays of the light, by which different refractions are caused; owing to the inequality of the surface, but if blood be examined in bright daylight, there is not the least appearance of spontaneous movements in the blood.

The notion of Eher and Meyer that the blood-globules are infusory animals is equally without foundation.

Treviranus, Mayer, and others have considered the movements observed in the red globules when observed between two pieces of glass, as depending upon spontaneous movements in the red particles - this is quite wrong for the same thing may be observed in blood

that has been taken from the body for a considerable length of time. It depends solely upon capillary attraction excited by the evaporation which is going on at the edges of the glass, or upon the same kind of attraction excited by the globules of air which occasionally collect between the glasses.

Some have described contractions and dilatations to go on during the coagulation of the blood, but this is denied by Müller and a host of observers.

Is the Blood endowed with Life -

That they do possess vital properties is now admitted by Müller, Carpenter and almost all physiologists - So that the notion of Hunter, though for many years ridiculed by successive lecturers and writers on physiology, is now the universally received doctrine - This has been principally settled by the discovery of cells with the Microscope - For it is now clearly proved that each red-globule is a nucleated cell, like those of plants - each separate and independant, and each having a separate and distinct life of its own -

Müller shows that the semen must be an animated fluid, not only from its carrying with it the power of fructifying the ova, but it also conveys the hereditary diseases and the family resemblance of the individual from whom it proceeds. The Blood likewise "manifests organic properties"; it is attracted by living organs which are acted on by vital stimuli; there subsists between the blood and the organised parts a reciprocal vital action, in which the blood has as large a share as the organs in which it

circulates. The fibrine of blood effused in inflammation is at first fluid, and forms as it becomes solid, pseudo-membranes, which afterwards, by means of a mutual vital action exerted between them and the organs by which they are poured out, become organised and traversed by blood & vessels"

The blood itself has, therefore, the properties of life, & so have all the secretions except those, whose office it is to remove the effete particles from the system, as the urine and Carbonic Acid. The saliva and Bile exert exert an assimilating action on the food, the different organs perform the same functions with regard to the blood, and here there is no clearly defined limit between substances capable of life and those endowed with it -" p. 154 -

Formation of the Blood -

Blood is formed from lymph and chyle. The former is derived from the organic structure of the body which is absorbed; the chyle is absorbed from the intestinal canal. Both are conveyed by the Thoracic Duct. The lymph has such a close resemblance to the Liquor Sanguinis as to authorise Müller to term it the lymph of the blood.

The Red particles. It is believed by many physiologists that the lymph globules already described are merely the commencement of the red globules - Müller however opposes this view, because the lymph globules of the Frog are spherical whilst the blood globules are elliptical - and also because the lymph globules of the Frog are only about one fourth the size of the Blood globule - Of this I have frequently satisfied

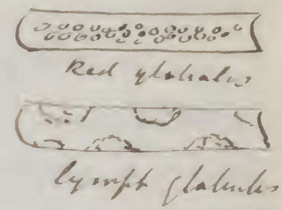
myself. But on the other hand many Physiologists affirm that the lymph globules are but the early form of the red globule – just as the roundish cell of the rete mucosum becomes the elliptical epithelial scale. The lymph globule of the Frog contains a nucleus which though at first small and insignificant becomes gradually larger, though the outer sac of the globule still retains the same size. If it can be proved that these spherical cells do take an elliptical shape from pressure and other circumstances, it will be easily seen how they can form the red globules – but though this is extremely probable, it has not as yet been clearly demonstrated –

Uses of the Red Particles. They are only found in the Blood of the Vertebrata: hence they cannot be indispensable to the organisation – they are most abundant amongst those classes that possess the greatest animal temperature, thus they are more numerous in Birds than in Mammalia, and in the latter they are more numerous than in Reptiles and Fishes. Globules of the mouse are larger than those of the Musk-deer – From the fact of their changing colour with in pulmonary and systemic capillaries, in the former changing from purple to red, and in the latter from red to purple, it would appear that they were engaged in some way in introducing oxygen into the blood that circulates through the systemic capillaries, & the removal of carbonic acid set free; to serve as the medium in fact, for bringing the tissues into relation with the air, the influence of which is necessary for the maintainance of their vital activity.

Liebig's Theory respecting the use of these globules -
The red globules contain iron - in a state of protoxide. This however has been converted into Proto Carbonate by meeting with Carbonic acid in the systemic capillaries - the blood now passes onwards to the lungs, the red globules retaining the iron, in a state of proto-Carbonate. On exposure here, to the atmosphere the iron sets free its carbonic acid and being now in a state of oxide, it takes a second atom of oxygen from the atmosphere, and is carried onwards again, to the capillaries, where it again meets with carbonic acid and having united with it, an atom of oxygen is set free and is imparted to the tissues - The iron in the globules goes on in the form of proto carbonate to the lungs, where the same change takes place -

Colourless Corpuscles - Besides the red discs, colourless globules have been discovered in the blood of Mammalia and man by Gulliver and Addison, though their existence was ascertained some time ago in the lower order of the Vertebrata. It is curious that though the characters and size of the red globules differ considerably in the various orders of Vertebrata, yet the colourless globules are almost identical in these respects in all. This is one argument against the theory that the red particles are formed from the Colourless globules. They possess likewise greater refractive powers, and when examined they always present themselves in an isolated

or solitary condition. In inflammation colourless lymph globules adhere to the sides of the vessels, while the red particles run in centre. Whilst the red discs are usually aggregated. This peculiarity obtains even after the glasses have been rubbed one against another. These white Corpuscles are identical with the lymph globules, occupying the exterior of the current.



In the Frogs foot the white corpuscles occupy the exterior of the current, whilst the red globules pass rapidly along the centre of it – the white corpuscles manifest a disposition to adhere to the walls of the vessel; which previously is greatly increased by employing an irritant to act on the skin of the animal.

State Carpenters view of the use of the Colourless corpuscles at p. 15. ~~[illegible]~~ of this lecture.

Besides the red corpuscles and the colourless globules, Gulliver has discovered in blood examined after death, an abundance of white matter, presenting itself in a spherical shape and semifluid consistence. This matter is found in greatest abundance in the mesenteric veins. These appear to be the fibrinous globules of Mandl: and are supposed to be Pathological developments – most probably tubercular –

Besides the changes already described as belonging to healthy blood, there is one more, viz a whitish or milky appearance of the serum, observed

in blood taken out a short time after a meal. This colour depends on the presence of large proportion of the granular base found in Chyle. The experiments of Dr Buchanan show that this appearance is attribu=table to admixture with the chyle. He has proved that if we take from an animal a small quantity of blood shortly before a meal, it will be deprived of the white appearance; if taken half an hour after it will become slightly turbid, and if we take a small quantity for the next six hours it becomes more and more white — after that however, it loses the milky appearance. (see Carpenter —)

there is reason to think that these cells have for their office the transformation of Albumen into Fibrine; that is to say, the elaboration of the spontaneously-coagulating and fibrillating substance, from the mere chemical compound which forms the raw material of the Animal tissues. For we find these cells in every situation, in which we know the transformation to be going on; and we observe their number to bear a close relation with the amount of fibrine produced in the fluid. Thus in the Inflammatory process, the quantity of fibrine in the blood is very greatly augmented, and the number of white corpuscles found in that fluid, when it is drawn from the body, is very largely increased. Moreover they are observed to accumulate in great numbers in the vessels of inflamed parts; and not only in these, but in all parts where processes of growth and reparation are going on, which require a large supply of highly-elaborated fibrine. They are found, too, in the exudations of fibrinous matter, poured out from the blood upon wounded or inflamed surfaces; and here they show the very same properties as the white or colourless corpuscles of the blood, — that is, they exhibit moving molecules in their interior; they burst & emit these when brought in contact with an alkaline solution; and their fluid contents show

a disposition to fibrillate, when they are not altered by any chemical reagent. Hence it may be concluded that they belong to the same class of cells; being probably developed from granular germs set free from the blood, along with the fibrinous exudation itself." see drawing -
(Carpenter's Manual p 125.) Fig 15. Carp. Man

13 214

Circulation

Lectures No 1 and 2

J D Gibb M.D.

25 and 26 June 1857

To illustrate

Circulation in fishes - Carpenter p 323
—do— in Reptiles —do— p 325
—do— in Birds —do— p 326
Fig 6 Muller Vol 1. p 173
Foetal Circulation, large, from Wilson.
Portal Vein, large, from do
Use Microscope to show circulation in Frog.
Some others illustrating Comparative Anatomy
Write ages down on Chalk.

What with showing the circulation in the frog, explanation of plates, &c the hour had elapsed at the 8th line page 7 -

For Second Lecture

drawing of Portal Vein
Quains plate of the Heart
One of Cloquets
Boerhaaves Physiology plate 8. Fig 2.

Circulation. Many absurd notions were entertained by the ancients concerning the circulation. One was, that, the arteries carried the air, or spirits to the heart, whilst the blood was conveyed by the veins. Another was, that the blood departed from the heart during the waking state of the individual, and returned to it, when he was asleep. Servetus (the victim of Calvinistic intolerance) had some notions as to the true phenomena of the circulation. He fully understood the nature of the pulmonic circulation, and was even well aware of the change effected upon the blood by the action of the atmospheric air in the lungs — but beyond this he was ignorant.

Proofs of the Circulation. (give these at page 5)

1 From observation in the web of a frogs foot.
2 The valves of the Heart which admit the blood to be passed on to the arteries, but prevent its entrance to the veins.
3 Transfusion.
4 Experiments of Lower
5 The Blood flows from the upper end of a wounded artery and from the lower end of a wounded vein.
6 Different states of the upper and lower end when a ligature is applied to the artery and to the vein.
7 Injection
8 The effects of medicines introduced into a vein, as Tartar Emetic, and specific action of poisons.

The Heart, lungs, arteries, veins and capillaries.

The Circulation was Discovered by Harvey 1619. His observations extended only to the higher animals. The discovery made by him, is now found to extend to almost all branches of the animal family, and Ehrenberg has shown that Currents quite analagous exist in the microscopic Rotatoria.

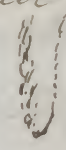
Circular Current in the lower Animals. have been discovered in the Chara & other animals, but these appear to depend upon action of ciliary processes, and not upon the propelling power of the heart, and even in some of the lower animals with ramified vessels, the currents are also caused by ciliary movements and not by a heart.

In the Planariae. Echinodermata, & leech tribe the circulation is carried on by the propelling power exerted by one or two contractile vessels, these are not either arteries or veins, but in short they act as hearts, propelling the blood into anastomosing branches.

In the Annelida. there is a progressive contraction of the vascular trunks, which take place in one direction and propel the blood forwards. From these, branches pass off on either side which at each contraction become distended. The principal trunks are placed ~~at~~ on either side, and as one contracts the other becomes filled.

Insects possess a dorsal vessel which propels the blood: in them there is one current of arterial and one of

venous blood; the arteries terminate in the veins and are continuous with them. The currents in these vessels run in opposite directions - each limb is supplied with an artery running down, and a vein returning.



In the Arachnidae or Spider Tribe & the Crustacea - the circulation is nearly the same as in the Insect tribe; there is no distinct pulmonary circulation but part of the blood becomes aerated in the respiratory organs. In those with Tracheae, the latter organ ramifies extensively through the body, and the blood supplying it becomes aerated.

In the higher crustacea (as the Lobster) there is either a long tubular heart, or a short wide one. The blood is collected by veins and by them brought to the branchiae, when it proceeds to the heart and thence is distributed to the body.

In the circulation in the Mollusca, it is similar to that in the Arachnidae and Crustacea.

The Cephalopoda possess three separate ventricles - one the systemic ventricle, drives the blood into the Aorta, where it traverses the arteries, returning by the veins it empties itself into the two lateral hearts, which drive it into the branchial vessels - they in their turn carry it back to the systemic ventricle and from this it goes through the Aorta & so on -

Fishes (Fig) have a single heart, i.e. they possess but one auricle and one ventricle. From the ventricle the blood is driven through the bulbus arterio

by the veins which unite to form the vena cava. There is no communication between the aorta and ventricle.

& There is a heart in the museum of McGill College, of a man, which has only 2 auricles and one large ventricle, similar in this respect to the heart of Reptiles.

In <u>Mammalia and Birds</u> the Heart possesses 4 Cavities, 2 auricles and 2 ventricles - there are 5 cavities in the <u>Crocodilus Nilus</u>.

sus to the branchiae by four branchial arteries, whence it is returned by the branchial veins, also 4 in number to the aorta and from this it is propelled through = out the body: there it is collected and returned to the auricle #

Reptiles (Fig) have 2 Auricles and 1 Ventricle. The venous blood brought from the body, to the right auricle is partially mixed in the ventricle with arte= rialized blood, which is received from the lungs by the left auricle and poured into the ventricle: from the right part of the ventricle the left aortic trunk and the left pulmonary artery arise; from the left cavity the right aortic trunk & generally the right pulmonary artery; it is from the right aortic trunk that the arteries of the head and upper extremities arise, and these parts, as in the foetus of mammalia & birds, receive a larger pro= portion of arterial blood: the two aortic trunks unite behind to form the descending aorta. &

Foetal Circulation. (Figure).

See Wilsons Anatomy & Carpenters Manual –

Portal Circulation this is merely an appendage, as it were of the general circulation. In fact, in it, the blood only makes an additional route before entering the heart with the rest of the venous blood. In the Mammalia it takes its course through the liver, and there is in many of the Reptiles, Amphibia and Fishes a portal circulation through the kidneys. The same

thing has been proved by Mr Bowman to take place in the human subject. His observations I shall postpone till we come to speak of the Kidneys.

In man and the mammalia, the portal vein is formed from the splenic, vesical, renal, intestinal and gastric veins and those from the pancreas — these uniting into one trunk enter the liver and ramify like an artery. The Veins which are supplied with blood from the hepatic arteries, join the portal veins and from the inferior cava which empties itself into the right auricle.

In reptiles part of the blood from the posterior extremities and that from the tail goes to the Kidney — the other part goes to the liver. see Proofs of Circulation at page 1.

Essential Characters of the Heart.

The principal impelling power of the circulation is the rythmic motion of the Heart. The heart is the muscular part of the Bloodvessels, and is endowed with the power of Contracting. In its simplest form it resembles a vessel; as may be seen in the Annelidae, whose hearts are merely dilatations of the vessel. The Dorsal vessels of Insects too, are divided into numerous compartments.

In the embryo of the higher animals the heart is at first tubular, and appears to be nothing more than the contractile part of the vessels. In the adult hearts of higher animals, the contractile substance of the heart is Continued on the veins — and in Fishes and Reptiles it is Continued on a part of the arterial

if lower than this in the unborn infant, say 110 and becomes intermittent, child will be born dead, unless immediately delivered through Ergot of Rye.

stem – which in these animals is called the Bulbus Arteriosus.

In the Frog, the trunks of the venae cavae may be seen to contract distinctly and regularly like the heart – this fact was observed by Haller, Spallanzani & Wedmeyer. Muller has observed contraction in the veins both of the young martin and of the Cat & other of the Mammalia –

The heart of adult man in the middle period of life contracts from 70 to 75 times in a minute. The frequency of its action gradually diminishes from the commencement to the end of life, thus: — write this on board.

In the embryo the number of beats in a minute is	150 *
Just after birth — — — —	from 140 to 130
During the first year	130 to 115
During the second year	115 to 100
During the third year	100 to 90
About the seventh year	90 to 85
About the fourteenth year	85 to 80
In the middle period of life	75 to 70
In old age	65 to 50

In persons of a sanguine temperament the heart beats somewhat more frequently than in those of the phlegmatic; and in the female sex more frequently than in the male. After a meal the heart's action is accelerated and still more so during bodily exertion; it is slower during sleep. The observations of Dr Guy and others have shown that, in a state of health, the pulse is most frequent in the morning, and becomes gradually

slower as the day advances; and that this diminution of frequency is both more regular and more rapid in the evening than in the morning. It is found, also, that, as a general rule, the pulse is more frequent in the standing than in the sitting posture, and in this than in the recumbent position; the difference being greatest between the standing and the sitting posture.

Order in which the different parts Contract.

If the heart of a living mammiferous animal or bird is laid bare, the two ventricles are seen to contract simultaneously, and the two auricles with the commencement of the pulmonary veins and of the venae canae, also simultaneously, the contraction of the ~~ventricles~~ auricles and that of the ventricles not being synchronous.

In warm-blooded animals the auricles contract immediately before the ventricles. In the frog the contractions of the venous trunks, of the auricles, the ventricle and the bulbus aortae, Muller has seen follow in the order of their being named, the intervals between the four contractions being nearly equal; so that the same interval of time elapsed from the contraction of the auricles to the contraction of the ventricle, as between the contraction of the ventricle and that of the bulb of the aorta.

In man and mammalia the contraction or systole of the Auricles takes place precisely at the same moment with the dilatation or diastole of the Ventricles; and, as soon as the latter are full, and

the former are empty; the diastole of the Auricles, and the systole of the Ventricles, immediately succeed. The systole of the Ventricles occasions the propulsion of blood into the arterial system; and this action produces the pulse, as will be explained hereafter. And it also corresponds with the impulse or stroke of the heart against the parietes of the chest.

The contraction or systole of the heart is active — the dilatation or diastole is passive. Bichat thought that the latter was active. His experiment — see his work

Oesterreicher opposes this view of Bichats and proves that the heart is not active during dilatation. He removed the heart of a frog from the body, and laid upon it a substance sufficiently heavy to press it flat, and yet so small as not to conceal the heart from view; he then observed that during the contraction of the heart the weight was raised, but that during its dilatation the heart remained flat. This experiment shows that the dilatation of the heart is not a muscular act. Muller p 185

The Contraction of the Ventricles would drive the blood into the auricles were it not for the valves — The Auriculo-Ventricular Valves — are the Tricuspid and Mitral —

The Tricuspid Valves are situated in the right ventricle. They are 3 triangular folds of the lining membrane, strengthened by a thin layer of fibrous tissue. They are

connected by their base around the auriculo-ventricular opening; and by their sides and apices, which are thickened; they give attachment to a number of slender tendinous cords, called chordae tendinae. The chordae tendinae are the tendons of the thick muscular columns (columnae carneae) which stand out from the walls of the ventricle, and serve as muscles to the valves. A number of these tendinous cords converge to a single muscular attachment.

The Mitral Valves are attached around the auriculo-ventricular opening, as in the tricuspid in the right ventricle. They are thicker than the tricuspid and consist of only two segments, of which the larger is placed between the auriculo-ventricular opening and the commencement of the aorta, and acts the part of a valve to that foramen during the filling of the ventricle. The difference in size in the 2 valves, both being triangular, and the space between them, has given rise to the idea of a "bishops mitre," after which they were named. These valves like the tricuspid, are furnished with an apparatus of tendinous cords, chordae tendinae, which are attached to 2 very large columnae carneae.

Mr Wilkinson King. Safety Value function of the Tricuspid Valve. He has shown, that though no regurgitation takes place through the left auriculo-ventricular opening, yet that there is a special provision in the Tricuspid valves to admit of regurgitation. If from any cause accumulation of blood

should take place in the right ventricle, great danger of its becoming paralysed from over distension or of rupture from the same cause, would be encountered. But from the peculiarity of the attachment of the Chordae tendinae of the valve, when the walls of the ventricle are over distended, the valve is drawn down and the blood is allowed to escape back again into the auricle and from this cavity into the Cavae and Jugulars. This explains the pulsation and turgescence of these latter vessels observed when the circulation through the lungs becomes impeded.

Dr Reid has also shown that when the right ventricle becomes paralysed from accumulation of blood in its cavity in asphyxia, that it will resume its contractions if part of the blood be allowed to escape through a puncture in the walls of the Ventricle or if blood be allowed to flow from the Jugular Veins.

On safety valve Functions. See Guy's Hosp Reports Vol II
also Wilson's Anatomist's vade mecum.

It is the general opinion that the Ventricles do not completely empty themselves at each stroke – that some blood still remains within their cavities.

The quantity propelled between each stroke may be estimated at 1½ or 2 oz. Taking 1½ as the standard & multiply by 75 the number of beats in a minute, we find that 7 lbs of blood pass through each ventricle in a minute. In a person of 140 lbs weight, 28 lbs is the amount of blood in his body according to ~~Haller~~ and

Allan Thompson: therefore this quantity would pass through in 4 minutes if we allow 1½ ℥ as the amount propelled at each stroke, and if we take 2 ℥, 3 minutes are only required. × of p. 302.

Impulse of the heart. At the commencement of each ventricular contraction, the heart may be felt to beat with a shock or impulse against the walls of the chest. This impulse is most evident in the space between the fifth and sixth ribs, between one and two inches to the left of the sternum. The force of the impulse, and the extent to which it may be perceived beyond this point, vary considerably in different individuals, and in the same individuals under different circumstances. It is felt more distinctly, and over a larger extent of surface, in emaciated than in fat and robust persons, and more during a forced expiration than in a deep inspiration; for in the one case, the intervention of a thick layer of fat or muscle between the heart and the surface of the chest, and in the other the inflation of the portion of lung which overlaps the heart, prevents the impulse from being fully transmitted to the surface. An excited action of the heart, and especially an hypertrophied condition of the ventricles, will increase the impulse, while a depressed condition, or an atrophied state of the ventricular walls, will diminish it.

The impulse of the heart is probably the result of several circumstances which, acting in combination,

have a tendency to rotate the whole organ from right to left, and to tilt its apex forwards and upwards, so that it is made to strike against the walls of the chest.

Apparently the most important of these circumstances is the contraction of the spiral muscular fibres of the ventricles; and especially of certain of these fibres which according to Dr Reid, arise from the base of the ventricular septum, pass downwards and forwards, forming part of the septum, then emerge and curve spirally round the apex and adjacent portion of the heart.

The condition which, next to the action of these fibres, contributes most to the occurrence and character of the impulse of the heart is its change of shape: for, during the contraction of the ventricles, it becomes more globular, and bulges so much that, according to Dr Mitchell and Dr. Kiwisch this change alone is sufficient to produce the impression of an impulse when the finger is placed over the bulging portion of the heart, either at the front of the chest or under the diaphragm.

The production of the impulse is, further assisted, perhaps, by the tendency of the aorta to straighten itself and diminish its curvature when distended with the blood impelled by the ventricle*; and by the elastic recoil of all the parts about the base of the heart, which according to the experiments of Kürschner are stretched downwards and backwards by the blood flowing into the auricles and ventricles during the dilatation of the latter, but recover themselves when,

* Hunter's view -

at the beginning of the contraction of the ventricles, the flow through the auriculo-ventricular orifices is stopped.
But these can be only accessory conditions in the perfect state of things: for the same tilting movement of the heart ensues when its apex is cut off, and no ~~change~~ tension or change of form can be produced by the blood.
The cause of the impulse must therefore be in the walls of the heart itself; and, when the apex of the heart is cut off, and the continuity of most of those fibres, to whose action are ascribed the impulse in the perfect state of the organ, is destroyed, then we may believe that the fibres remaining in the body and base of the heart, and having the same general spiral direction from right to left and from above downwards, are sufficient to produce a similar tilting movement.

Sounds of the Heart. When the ear, or a stethoscope, is placed over the precordial region, two sounds are heard following each other quickly at every beat of the heart, which follow in quick succession, and are succeeded by a pause or period of silence.
The first sound is dull and prolonged; its commencement coincides with the impulse of the heart, and ~~[illegible]~~ precedes the pulse at the wrist. The second is a shorter and sharper sound, with a somewhat flapping character, and follows close after the arterial pulse, it is more intense than the first.
If the period of time occupied by the two sounds

and by the subsequent pause, — which together constitute the rythm of the heart, — be divided into four equal parts, the first sound, and the very short interval between it and the second, will be found to occupy the first two parts, or half the period of the rythm; the second sound rather less than another part, and the pause rather less than the fourth part.

Laennec supposed first sound to depend upon contraction of the ventricles, and the second to contraction of the auricles - but the reverse is the fact.

Pilon supposed the first to depend upon attrition of the blood from the ventricle to the auricle.

Other physiologists have supposed the first sound to depend upon contraction of the auricles, the second to contraction of the ventricles.

Magendie attributes the first sound, as we do, to the contraction of the ventricles, and to the impulse of the apex of the heart against the ribs; the second, to a similar impulse produced by the dilatation. The experiments of Dr Hope and M. Bouillaud were unfavourable to his theory of the second sound -

M. Bouillaud attributes both sounds to the action of the valves.

The correct theory and the one now adopted by most physiologists is that of Dr Williams -

He considers the first sound as produced by the contraction of the ventricles, and the second by the flapping

each of the pulmonary and aortic valves.

The first sound is regarded as compound in its nature, being made up of the sound produced by the impulse of the heart against the parietes of the chest; of the muscular sound occasioned by the forcible contraction of the thick walls of the ventricles, and of the sound generated by the friction of the particles of the blood against each other, and against the boundaries of the narrowing orifices which lead into the vessels.

The cause of the second sound is simpler, and more easily understood. It is due to the sudden filling-out of the semilunar valves with blood, at the moment when the ventricular systole has ceased, and when the commencing diastole produces a tendency to the regurgitation of blood from the aorta and pulmonary artery. That this is the real cause, has now been fully ~~determined~~ demonstrated. If one of the valves be hooked back against the side of the artery, by the introduction of a curved needle, so that a reflux of blood is permitted, the sound is entirely suppressed. And if the complete closure of the valves be prevented by disease, so that their tension is diminished, and a certain amount of regurgitation takes place, the second sound is no longer heard in its intensity; whilst on the other hand, a sound analogous to the first, and sometimes prolonged over

the whole interval of repose; indicates the reflux of the blood into the ventricles. When the semilunar valves are thickened by marked deposit, their surface roughened, and their opening narrowed, the first sound becomes harsher and sharper; and the second sound acquires the same character, — the backward as well as the forward flow of the blood being affected by this cause.

Pulmonic Circulation - Lesser -

Describe this - see Müller - 188 - and others -

Systemic Circulation or greater -

Describe this - see Muller - 192. 3. 4. 5

Portal Circulation - (Figure)

see Müller p 195 - and Wilson p 384 & 580 -

Rate of the Bloods motion. We cannot judge of the rate at which the blood moves by the appearance of rapid motion it presents when escaping from a cut in a vein - Reason - Pressure of whole column against the opening when the ordinary resistance is taken off.

Herings experiment with the Ferrocyanide of Potassium - who endeavoured to ascertain the rapidity of the circulation by introducing this substance into one part of the system, and drawing blood from another -

"Time required for the passage of a solution of Fer. Cy. Pot of different strengths, which was mixed with the blood, from one jugular vein (through the right side of the heart, the pulmonary circulation, the left cavities of the heart, the general circulation) to the jugular vein of the opposite side, varied from 20 to 25 or 30 seconds."

Carpenter Elements p 423. 24 & Muller p 197 -

It required 20 seconds to pass from the jugular vein to the great saphena vein - 15 seconds from the jugular vein to the mesenteric artery. the other experiments are of a similar nature.

Blake fully confirmed the experiments of Hering - He injected a solution of Nitrate of Baryta into the Jugular vein of a horse. He detected the poison in the blood of the Carotid Artery, drawn between the 15 & 20 seconds after its first introduction into the vein -

It is now however proved that the Complete

circulation of the blood in man, takes place in from one to two minutes.

Cause of the Contraction of the Heart.

Soemmering, Behrend and Bichat, denied the influence of galvanism upon the heart. this opinion disproved most satisfactorily by Müller.

The Blood Contained in the heart has been supposed to be the cause of its contraction. 1st by its acting as a chemical irritant. 2nd by the stimulus of distension. Both these views disproved by the Experiment of Mayo, who found that the heart of a dog pulsated strongly for some time removed from the body, and when empty of blood, it was placed in a tub of water. And Dr Mitchell (Amer. Jr of Med: Sciences) found that the heart of a Sturgeon inflated with air, continued to beat until the auricle had absolutely become so dry as to rustle during its movements.

Some suppose that when the heart is empty, the stimulus of air on its internal cavity is the cause of contraction — this is disproved by the experiment of Dr John Reid, who placed a Frogs heart under the air pump & yet pulsation was continued.

Alisons opinion. He thought that from the arrangement of the fibres of the Heart, that in the contraction of one set, they pressed upon and irritated another set, and thus induced a series of contractions.

3rd The Stimulus of the nervous power. Le Gallois

thought that it was independant of nervous power (because it beat for sometime after the Spinal marrow was crushed .. Objection - Le Gallois forgot that the nerves of an organ have in themselves the power of generating nervous power.

Dr Wilson Philip found that if the spinal marrow be crushed gradually and not instantly, the movements of the heart will not be arrested -

Haller denied the influence of the nerves upon the circulation, because the heart acted when removed from the body; and because irritation of the cardiac nerves did not produce any contraction of the organ. This view of Hallers appeared to obtain confirmation from the statements put forward by Behring & Soemmering, that the heart receives no nerves, for they maintain that the cardiac nerves were distributed upon blood vessels of the heart, and did not enter into its muscular structure. They also stated that Galvanism produced no effect upon the heart.

Scarpa has however proved that the heart receives nerves in very great abundance; & Humbolt: Pfaff Fiedemeyer & Müller have produced contraction of the heart from Galvanism.

Humboldt & Burdach go farther; they state that by applying the wires to the cardiac nerves, they have succeeded in producing contractions of the heart. To this, it has been objected, that the nerves, in these experiments may have acted only, as moist conductors of the electricity to the muscular structure of the heart.

What part of the Nervous System has influence over the Hearts action — This was first investigated by Bichat - Legallois experiments prove - that if the medulla oblongata and the spinal nerves be destroyed, respiration will cease, but the hearts action tho' greatly impeded will still continue for some time, and the strength of the hearts action: but the strength of the hearts contractions cannot be re-excited by artificial respiration.

2nd If the spinal cord be destroyed at distinct intervals by cutting off slices, the hearts action is not so soon destroyed as when the cord is destroyed at once.

3rd The introduction of wires into the spinal cord from below, also stops hearts action; in this case also it is not restored by artificial respiration.

These experiments led Legallois to conclude that the heart is under the control of the whole spinal cord and not under any part of it in particular -

The inference which Legallois drew from his experiments was that the sympathetic nerve had no influence over the circulating organs, and that it merely served to connect these parts with the spinal marrow, and to act as a bond of union between them, conveying to those organs the motor influence of the spinal Cord -

Wilson Philips experiments prove the very opposite of Legallois views - He has found that when the brain and medulla oblongata are destroyed by a

blow of a hammer, and the spinal cord itself destroyed by introducing a red hot wire through its whole length, that the respiration ceases, but the heart will continue to act and remain acting for some time if artificial respiration be kept up, and the same thing is observed if the Brain and Spinal Cord be removed by the Knife.

Wilson Philip also proved that if spirits of Wine be applied to the brain of an animal, the hearts action will be greatly increased — the same result followed the application of Opium & Tobacco; in both which cases, the stimulating effect of these medicines became manifest before the sedative influence was established. Wilson Philip infers, that the "heart through the medium of its nerves stands in relation with all parts of the Brain and Spinal marrow, — while individual voluntary motions are connected only with individual parts of the brain and Spinal cord".

Muller p. 207.

Flourens was of opinion that the continuance of the Circulation depended upon the respiration, for the former ceased when the latter was interrupted, and as the respiration ceases when the medulla oblongata was removed, (from which the nerves of respiration arise) he concluded that all other parts of the brain and spinal marrow might be cut away without causing the respiration to cease. Marshall Hall has shown however that the hearts of some Fishes will

continue to beat long after the Brain and spinal marrow have been removed.

From the foregoing experiments of different inquirers and from his own views Müller deduces the following propositions.

"1st That the Brain and spinal marrow have a great influence on the motions of the Heart: through its agency it may be accelarated or retarded, depressed or invigarated.

2nd That the hearts action may continue for a short time after removal of the Brain and spinal marrow.

3rd That complete removal of the heart from the body, is not instantaneously followed by cessation of the hearts action." Muller p. 208.

In Acephalous Faetuses the independance of the heart with the Brain is well shown; but in these Cases, when the brain is completely absent, the Heart is generally absent too.

Force with which the heart propels its blood, is such that if a vertical pipe be inserted into the Carotid artery of a Horse, the blood will sometimes rise to the height of 10 feet. From comparative experiments upon other animals, it has been estimated that the vigorous action of the heart in Man would sustain a column of blood in his aorta about 7½ feet high; or in other words, that the force with which the heart ordinarily propels the blood through the aorta, is equal to that which would

be generated by the weight of a column of blood of the same size, and 7½ feet high; which weight would be about 4⅓ lbs. But the force which must be exerted by the heart to sustain such a column, may be shown, upon physical principles, to be as much greater than this, as the area of a plane passing through the base and apex of the left ventricle is greater than that of the transverse section of the aorta; and as the proportion of these areas is about 3:1, the real force of the heart may be stated at about 13 lbs.

15

Lymph and the Lymphatics.

J. D. Gibb M.D.

28th June 1857

To illustrate

Lymph Heart - Muller -
Lymphatic Vessel and Glands in Em & Am Kirkes
Thoracic duct
Fig 78. 79. 80. Carpenter
p 279 Muller - Vagel &c
Number of Cloquets plates
Boerhaves Physiology plate 14.

Lymph and the Lymphatics -

Lymph is a transparent yellow fluid - without any tint of red. In the frog it is perfectly transparent and not even yellow - devoid of smell, slightly alkaline, and has a saline taste -

Lymph of the intestines is called Chyle -

Analysis - Both lymph and chyle contain albumen and fibrine in a state of solution - Fibrine of lymph removed from the body coagulates in less than ten minutes -

Emmert found that 92 grains of lymph of a horse contains only one grain of soft coagulum, consequently less than one-third per cent of dry fibrine -

Professor Nasse of Bonn & Müller procured lymph from the foot of a patient who was in Wutzer's wards, and they found that it was quite identical with lymph taken from the frog).

Muller examined it for globules, in order to confirm the observations of Tiedemann, Gmelin, Brande and others - These physiologists maintained that they could not discover any. Hewson said he did - Muller coincides with Hewson, and states that he distinctly observed colourless globules -

Lymph can always be obtained from the subcutaneous cellular tissue of a frog. See Müller p 278

The lymph globules of Frogs are about one fourth the size of the blood globules of these animals, they are also round. These lymph globules are quite identical

with those of the Human Body.

These lymph globules are not smooth, but rough and granular - Vogel renders a nucleus visible by the action of acetic acid - (See Figures

Though these globules may vary in size, their nuclei retain in all pretty much the same size - Bayley also asserts that they resemble the Blood-globules in being elastic as is shown by their undergoing a change of form when they meet with obstacles -

The lymph is generally colourless, but it has been observed of a dirty reddish colour in animals that had fasted for a long time - Müller has also seen it of a dirty red in the lymphatics on the spleen of an ox.

The chyle is always more opaque than the lymph of the same animal - The chyle in the Thoracic Duct of the Horse has a reddish tint quite peculiar to that fluid in that animal.

Forms in which the Absorbents take their rise -

1st - as a Network - the meshes of which are sometimes smaller than the minute lymphatics which form them - The second form in which the absorbents take their rise, is in the form of small cells of various sizes, communicating with one another - The resemblance between this form of the absorbents and the ordinary Cellular tissue is so striking as to have induced Fohmann, one of the most successful

injection of the Lymphatics, to conclude that what we call cellular tissue is merely this second form of the absorbent vessels.

The lymphatic vessels or absorbents are minute, delicate and transparent vessels, remarkable for their general uniformity of size, for a knotted appearance which is due to the presence of numerous valves, for the frequent dichotomous divisions which occur in their course, and for their division into several branches before entering a gland.

In their course they are interrupted by numerous small spheroid or or oblong bodies, more or less flattened on their surface, lymphatic glands.

The lymphatic vessels entering these glands are termed vasa inferentia or afferentia, and those which quit them vasa efferentia.

The vasa inferentia vary in number from 2 to 6, they divide at the distance of a few lines from the gland into several smaller vessels and enter it by one of the flattened surfaces.

The vasa efferentia escape from the gland on the opposite, but not infrequently on the same surface; they consist like the vasa inferentia at their junction with the gland of several small vessels which unite after a course of a few lines to form from 1 to 3 trunks, often twice as large as the vasa inferentia.

(Show Cloquets large plates)

The Lymphatic vessels are divided into superficial, deep and Lacteals.
The superficial lymphatic glands are placed in the most protected situations of the superficial fascia, in the hollow of the ham and groin in the lower extremity, and upon the inner side of the arm in the upper extremity.
The deep lymphatics fewer in number and somewhat larger than the superficial accompany the deeper veins. They terminate in a large trunk, over the vertebral column; the Thoracic duct.
In consequence of the great freedom of anastomosis between the inferential and efferential vessels, we can inject the efferent vessels from the vasa in afferentia.
The Lacteals are the vessels of the small intestines; they have received their name from conveying the milk-like product of digestion, the chyle, to the great centre of the lymphatic system, the thoracic duct. They are situated in the mesentery, and pass through the numerous mesenteric glands in their course.
The lacteals of the small intestines arise partly in the centre of each villus as a coecal tubules, which opens into a fine network situated in the submucous tissue; — and also from the whole surface of the mucous membrane of the small intestines. From this areolar network the lacteal

vessels proceed to the mesenteric glands, and from thence to the thoracic duct, in which they terminate. When they are injected with mercury, none of the metal escapes into the cavity of the intestine, so that the supposition that they commenced in open mouths cannot be maintained.

It is still an unsettled question whether the globules of the chyle enter the lacteals already formed. The varying appearance of the chyle corresponding to the change in the diet, affords the principal argument for supposing that the globules are taken up from the cavity of the intestine already formed. But how do they get there? Where are the openings by which they enter these vessels? they are not visible!

Structure of Intestinal Villi. Fymm that processes a quarter of a line to a line, or at most a line, and two thirds in length — arising from the surface of the mucous membrane. They are sometimes cylindrical, sometimes lamellar & pyramidal — These villi are highly vascular their vessels can sometimes be seen with the naked eye — They are devoid of opening.

Muller, Rudolphi & Meckel have discovered cavities in the Villi.

Mr Goodsir has discovered these villi are covered with a thin membrane, analagous to what is found

under the epidermis and epithelium of the skin and mucous membrane. This is seen only when digestion is not going on. The space intervening between the capillaries and the commencing branches of the Lymphatics, is occupied by a number of spherical vesicles or cells varying in diameter from the 1.100th to the 1.2000th of an inch. At the part where the vesicles approach the granular texture of the substance of the villus, minute granular or oily particles are seen. When the intestine contains no more chyme, the vesicles disappear almost entirely, the lacteals empty themselves, and the villi become flaccid; the epithelium which had fallen off during the process of absorption, is then removed.

<u>Intestinal Mucous Membrane</u> Description of it
Read Todd &c

<u>Absorbents</u>. Birds have them only in the neck; Fishes and Reptiles have none.

<u>Glands</u> are merely formed of a congeries of these inferent and efferent branches.

<u>Absorbent vessels</u> possess (like arteries and veins) three coats. An <u>external</u> or cellulo-fibrous coat, like that of bloodvessels, it is thin but very strong.

2 <u>Middle</u> coat, thin and elastic, consisting of a layer of longitudinal fibres analagous to those of the inner most layer of the middle coat of arteries and veins.

in internal coat, inelastic, and more liable to rupture than the other coats. It is a serous layer continuous with the lining membrane of the veins, and invested by an epithelium. The valves are composed of a very thin layer of fibrous tissue coated on its two surfaces by epithelium.

The Thoracic Duct has its three coats, the same as the absorbent vessels just described, it has fewer valves in its course than Lymphatic vessels generally; at its termination it is provided with a pair of semilunar valves, which prevent the admission of venous blood.

It commences in the abdomen by a triangular dilatation, the receptaculum chyli, in front of second lumbar vertebra, behind and between the aorta and vena cava. Continue its course from the Plate.

It is equal in size to the diameter of a goose quill at its commencement.

The opinion which is entertained by some that the absorbents communicate with other tubes, such as the lactiferous and the hepatic ducts is quite untenable. And the connection with arteries of which Magendie has spoken is equally incorrect.

The connexion of the small Lymphatics with the veins has been put beyond doubt by the experiments and researches of Fohmann. This junction can be detected in the thighs of Birds & of Fishes and Reptiles, though not so evident in man

and mammalia. These latter having absorbent glands, have the connection taking place in these glands. In the Seal and some other animals, as the dog & dolphin, there is a mass of absorbent glands called the "pancreas Aselli". All the lacteals enter this body, and one large efferent vessel proceeds from it, called the ductus Rosenthalicus.

The Absorbents all terminate in the Thoracic duct, and this in the left Subclavian vein, as I have already stated. The lacteals take the chyle to the lymphatic glands, which take it to the receptaculum chyli, commencement of thoracic duct.

Lymph Hearts. (Figure) In reptiles and some birds, an important auxiliary to the movement of the lymph and chyle is supplied in certain muscular sacs, named Lymph-hearts. The number and position of these organs vary. In frogs and toads there are usually 4, two anterior and 2 posterior; in the frog the posterior lymph heart on each side is situated in the ischiatic region, just beneath the skin; the anterior lies deeper, just over the transverse process of the 3rd vertebra. Into each of these cavities several lymphatics open; the orifices of the vessels being guarded by valves, which prevent the retrograde passage of the lymph. From each heart a single vein proceeds and conveys the lymph directly into the venous system.

Blood is prevented from passing from the vein into the lymphatic heart by a valve at its orifice.

The muscular coat of these hearts is of variable thickness; in some cases it can only be discerned by means of the microscope; but in every case it it is composed of transversely striated fibres: the contractions of these hearts are rythmical, recurring about 60 times in a minute, slowly and in comparison with those of blood hearts, feebly.

The pulsations of these sacs are quite independant of those of the heart, and continue when the heart is removed from the animal, even after the body of the animal is cut in pieces.

Functions of the Absorbents The red particles in their passage along the circulatory tract exert a vivifying influence upon the parenchyma, and undergo a change in their colour; but they are not arrested in their progress and pass from the small tubes into the veins. But the fluid constituents of the Blood, containing the albumen and fibrine in solution, percolate the walls of the capillaries and are imbibed by the particles of tissue contained in the network of the capillaries. These ingredients become dissolved and thus afford nutrition to the structures containing them. Hence Venous blood contains less fibrine than arterial. After serving the purposes of nutrition, the fluid portion of the blood, is again imbibed by the lymphatics

and by them carried to the thoracic duct, and thus enter the circulation again.

From the fact that the fluid portion of the blood after affording nutrition to the parts, is again returned to the blood by the lymphatics, it is clear that it and lymph are perfectly identical. This has been still further proved by Müller, who has found that if frogs be kept out of water for some days that their blood loses the power of coagulating, and he has also observed that the lymph of the same frog has also lost its power of coagulating.

Proofs that the lymphatics absorb. 1st they are often found filled with matter the same as that contained in diseased parts. 2d They become painful and red when irritating matters are applied to the parts with which they are in connexion 3rd Assalini, Saunders, Mascagni & Soemmering have detected bile in the lymphatics of the liver in cases where the Bile Ducts were blocked up. Tiedemann & Gmelin have found bile in the lymphatics of the liver of a dog, whose ductus choledicus they had tied.

4th Lymphatics around osseous tumours have also been seen filled with calcareous matter. 5th Mr Hunter found the lymphatics in the vicinity of the nose to be filled with Spermaceti and oil in the Spermaceti whale –

Magendie & Dupuytren have both met with instances in which the lymphatics leading from abscesses

were filled with pus, but Andral has never met with an instance of this.
The same difficulty exists here as with respect the globules of chyle. namely that there are no apertures sufficiently large in the coats of the lymphatics to admit of the passage of pus globules, which are also much larger than the largest blood globule. The fluid portion of pus or the Liquor puris can be readily absorbed, but when pus is found in the lymphatics, Müller thinks it is owing either to inflammation of the lymphatics themselves or mechanical solution of continuity in the walls of the lymphatics.

Magendie first questioned the absorbing power of the Lymphatics. Hunter had stated that on injecting coloured fluid into the abdomen of an animal, it is soon discovered in the lymphatics. Magendie states that he and Dupuytren repeated this experiment more than 150 times without obtaining the same result. Schroeder [van der K]olk have however observed a slow absorption of foreign matters from the intestinal canal.

The Philadelphia Academy, Lawrence, Coates & others have shown that Prus: of Pot: and other soluble salts are absorbed, but that colouring matters are not absorbed, by the Thoracic duct, though they were detected in the blood.

Almost all experiments prove that the lymphatics absorb only Salts, & no other kind of foreign bodies.

+ John Hunter thought that the Lymphatics were princi= pally useful in superintending the modelling of the body. Conceiving that the Lacteals were prin= cipally engaged in nourishing the body, he attri= buted to their [illegible] the modelling or laying out of this nourishment —

* If there is time explain Capillary Attraction —

In the many experiments made by Tiedemann & Gme[lin] salts were the only substances that they could [d]etect in the chyle.

From the foregoing premises the following conclu[s]ions may be drawn. 1st that the Lymphatics [do] really absorb. 2nd that this action is confined [to] particular fluids. 3rd that they have but little [te]ndency to take up foreign matters, of which salts [ar]e more frequently absorbed than colouring matters. [4]th they are principally engaged in absorbing the [L]iquor Sanguinis.× 5th that besides this fluid, they [li]kewise absorb small molecules which are taken [u]p from the parenchyma of the organs and the [g]lobules of the lymph —

Hence it is evident that the phenomena of ab=[s]orption in the Lymphatics differs from the process [by] which the Capillaries imbibe all foreign matters [in] a state of solution, or the process by which [th]e radicles of plants absorb - matter held in [s]olution - (see Muller p. 298)

What is the Power by which the Lacteals & Lymphatics [a]bsorb? Müller admits that to him it is quite [a] puzzle. Some have supposed Capillary attraction [b]ut here it is necessary that the capillaries [s]hould be empty - *

[M]üller says some kind of attraction must be [e]xerted by the absorbents - but offers no satis=[fa]ctory explanation of the nature of this attraction".

[Lymph]atics m[ay] ... modelle[d] ... [La]cteals ... the body ... [...]ling or ... attraction

At one time he thought that it was caused by contrac=
tion of the muscular coat of the intestine which urged
the chyle onwards, a retrograde movement of which was
effectually prevented by the valves of the lacteals – But
fishes have no valves in their absorbents. He therefore
thinks that the attraction is of a vital nature and quite
distinct from physical attraction such as what is
termed "Capillary" –

He says he has never seen any motion in the
villi of the intestines even in the living rabbit, nor
in the lacteals, receptaculum chyli or thoracic duct.
He has applied galvanism to the thoracic duct without
being able to produce any contractile movement –
It has muscular fibres, as I have already told you –

The ascent of the sap and of the lymph is closely anal=
ogous – but in plants the process is effected solely
by the action of the roots and spongioles, while the
villi of the intestines are not essential organs for the
absorption of the chyle – for the lymph is absorbed
in other parts of the body just as well as in the
intestines, and moreover there are many animals
who have no villi in their intestinal mucous
membrane –

Dutrochet explained the phenomenon of absorption
by Endosmosis – Explain this term –

The absorbents exert some important change upon
the Composition of the chyle & lymph. The fluids have the

same action - Tiedemann & Gmelin found that the Chyle would not coagulate spontaneously before it had passed through the absorbent glands of the mesentery. the walls of the absorbent vessels and the glands have then some peculiar power by which they convert the albumen of the Chyle into fibrin

Absorbents also take up foreign matters, as Syphilis, Gonorrhoea (bubo), morbid poisons introduced under the epidermis +

Explain here the phenomena of lymphatic Inflammation - Course of lymphatics well shown in arm, in dissec: wounds.

What are the powers that move the Chyle

Müller thinks the lymphatics must have some impercep=tible progressive motion - the nature of which he does not define - Tiedemann & Gmelin could produce no contraction in the Thoracic Duct by galvanism, but they found that on puncturing the Duct, that the Chyle poured out in a jet; from which they infer that the lymphatics though not endued with Rythmic Contraction have still the power of propelling onwards their contents - but this is only supposition.

Sucking action of the heart is not the cause - for if a ligature be put upon the Duct, the part below it will become distended -

It depends probably on the absorption going on in the radicles of the absorbents and is continued like the ascent of the sap -

<u>Rate of Motion of the Lymph</u> in the lymphatics is quite unknown - Some idea of the rate at which the chyle mones, may be formed by observing the time required for the distended lacteals in the mesentery of an animal just opened to become invisible, and by ascertaining the quantity of the fluid which can be collected from the thoracic duct - In <u>Magendie's</u> experiment half an ounce of chyle was collected in five minutes, from the thoracic duct of a middle sized dog.

Composition of Lymph and Chyle.

	Chyle	Lymph
Water	90.237	95.536
Albuminous matter (coagulable by heat)	3.516	1.200
Fibrinous matter (spontaneously coagulable)	0.370	0.120
Animal extractive matter, soluble in water and alcohol	0.332	0.240
Animal extractive matter, soluble in water only	1.233	1.319
Fatty matter	3.601	a trace.
Salts; — Alkaline chloride, sulphate and carbonate, with traces of alkaline phosphate, oxide of iron	0.711	0.585
	100.000	100.000

<u>Carpenter's Manual</u>

Absorption

J. D. Fitch M.D.

1 July 1857

To illustrate

Fig 29. p 255 Kirkes

Endosometer p 271 show it with fluid interg.
say prus: pot &c -

Too short, add 4 pages, including quantities
but introduce other practical matter besides
the experiments described.

Absorption - The absorbent system is composed of four parts - 1st The Lacteals - 2nd The Lymphatics 3rd The Conglomerate glands 4th the Thoracic Duct -

Until the discovery of the Lacteals by Asellius in the year 1622, and subsequently of similar vessels the lymphatics, it was usually supposed that the process of absorption was carried on solely by the veins.

Asellius discovered them accidentally; whilst engaged in examining the abdominal Viscera of a Dog he observed a series of vessels which did not appear to have any connexion with either the arteries or the veins, & from their containing white fluid he denominated them Lacteals - He discovered that they were a distinct set of vessels, having their origin in the mucous membrane of the intestines, but their termination in the Thoracic duct remained unknown till the year 1651 when this discovery was made by Pecquet -

Proofs that the Lacteals are really absorbents

1st They become turgid with chyle soon after taking food.

2nd And the arrangement of their valves is such that they admit the chyle towards the Thoracic Duct, whilst they arrest its passage backwards towards the intestine. These circumstances show that they are destined for absorption -

They are not the sole agents in absorption -

1st The absorption of the osseous matter in the interior

[th]e bones, cannot be due to the action of the lymphatics,
[f]or none have ever been discovered in them, & and the
[ab]sorption of the alveolar processes in old persons are
[l]ikewise independant of the action of lymphatics.
2nd Pus, portions of the lens, and blood in the interior
[of] the eye, as the Anterior Chamber, are likewise absorbed
[bu]t no lymphatics are to be found here.
3rd The absorption of the yolk of the egg by the ger=
[m]inal membrane - in which there are no lymphatics
[d]uring the first days of incubation.

Proofs of absorption by the Blood Vessels.

[M]agendie & Delille 1st Experiment. They divided all
[p]arts of the thigh of a dog, except the crural artery
[an]d vein - and having introduced 2 grains of the
[p]oison of the Upas ticute into a wound in the foot,
[th]ey found that poisoning took place, as rapidly as if
[th]e limb had not been meddled with. The symptoms were
[p]resent in 4 minutes, and in 10, the animal was dead.
[Se]cond Experiment - Having made the lacteals of a dog
[v]ery visible by giving the animal a full meal, they
[in]cluded a small portion of the intestine between two
[li]gatures, and the lacteals arising from this portion
[o]f the intestine were each tied with two ligatures,
[a]nd then divided. They satisfied themselves that no
[o]ther lacteals ran from this part of the intestines.
They next injected into the intestine, two ounces of
[a] decoction of nux-vomica; symptoms of poisoning

came on in six minutes, which could only be accounted for by the Veins having acted as absorbents on this occasion.

Third Experiment. Magendie, dissected from surrounding parts the Jugular Vein of a young dog, so as to enable him to pass a card underneath it. He then applied only a Spirituous Extract of Nux Vomica; the symptoms of poisoning appeared in 4 minutes - with an old dog it required 10 minutes.

Fourth Experiment. Segalas corroborated these experiments by including a portion of intestines in the same way as Magendie had done, and after dividing the blood vessels, he introduced a strong poison into the Intestines, and was unable to kill the animal after an interval of an hour.

Fifth Experiment. Mayers Exp: with the Prussiate of Potash injected into the lung. This must be read to class from Müller p. 255 - as it contains too many details for ready committal to notes.

Academy of Medicine of Philadelphia. Their Experiments. These are supposed to upset the conclusions of Magendie, but Müller thinks they are inconclusive. When a solution of Prussiate of Potash was injected into the peritoneum, a solution of Sulphate of Iron, applied to the Chyle 25 minutes afterwards, produced in the greater number of cases, a distinctly blue colour, whilst scarcely a tinge was produced in the serum

of the blood and in the urine. Müller objects to the interval of 35 minutes, which he thinks is too much. He says that they should have examined both the blood and the urine a few minutes after the experiment was performed as in Mayers case. He says these experiments only prove that the lymphatics absorb, chemical substances as well as the veins —

He adds that in Experimt: 38. after making a cut swallow an ounce of a solution of Prussiate of Potash; two minutes afterwards the animal died from loss of blood — they failed to obtain prussiate of potash in the serum, though they detected it in the urine, where it could have arrived only through the medium of the bloodvessels.

The Experiments of the Academy prove that these substances may be absorbed by the lacteals, but they do not prove that the veins are incapable of absorption —

Experiments of Tiedemann & Gmelin. They introduced colouring matters easy of detection into the stomach, and several hours after they could not detect any in the chyle though they found them in the blood and urine. Out of several experiments they only met with 2 or 3 examples of the passage of the colouring matter into the chyle, & then there was hardly a trace to be found.

It might be objected, that the matters were already all absorbed, but they found that they

existed in great abundance still in the intestines.
These Experiments are opposed to those of Hunter, Haller, Blumenbach &c.

Fodera filled a portion of the intestine of a living animal with a solution of prussiate of Potash, and then dipped it into a solution of sulphate of Iron, the Lacteals and Veins became blue. Schroeder von der Kolk found, in repeating this experiment that the lacteals only became blue. Müller objects to this except 1st that owing to the more rapid circulation in the bloodvessels the prussiate may have been carried off whilst it was only advancing slowly in the lacteals & 2nd that it is at all times almost impossible to detect a blue colour in the blood in the veins —

Pouseuille detected Prussiate of Potash, five minutes after it was introduced into the intestine of a rabbit, both in the lacteals and Veins —

Sir Benjamin Brodie & Magendie have made experiments respecting the effect that ligature on the Thoracic Duct has upon absorption. In Brodie's experiments though the Duct was tied, the animals were poisoned with wararee and alcohol.
But in Consequence of the Duct communicating in some animals with the veins, and presenting two ducts in other instances, we cannot be certain that the poison did not get into the Blood —

Emmerts Experiments. 6 Prove that matters pass immediately into the blood, for they do not enter the circulation when the abdominal aorta is tied.

1st The abdominal aorta was tied, Angustura Virosa and Prussiate of Potash were introduced into different wounds in the feet - the P. of P was detected in the urine, but no poisonous effects followed from the Angustura —

2nd - the abdominal aorta was tied - Prussic Acid was introduced into a wound in the foot. No effects followed after seventy hours, but when the ligature was removed the symptoms followed in less than half an hour —

Jacobson - has shown that Prus: of Pot: finds its way into the blood of the Mollusca, from every point of their surface, though they are destitute of lymphatics - Müller contends that the effects of poisons are solely due to the conveyance of the matter to the Brain by the circulation and not through nervous connexion -

Imbibition. the entrance of all matters into the blood, was until lately supposed to depend upon the absorbing power of the veins — but it is now known that many tissues both in the living and dead state admit of the transmission of fluids, by virtue of their invisible porosity this is what has been termed imbibition, or inorganic absorption to distinguish it from lymphatic absorption.

Endosmosis and Exosmosis - Explain this fully. Consult Muller p 257. & the article by Dutrochet in Todds Cyclopaedia -

Carp. p 257.

Müller made the following experiment in order to ascertain the length of time it required for substances in solution to come in contact with the capillary vessels, in parts not covered with Epidermis - He stretched the recent bladder of a frog over the neck of a bottle containing a solution of Prussiate of Potash, and having wet the upper surface of the bladder with the Muriate of Iron, he inverted the bottle, when in the space of a second a blue colour was perceptible upon the bladder - Now as the bladder is much thicker than the covering of the intestinal villi, he infers that substances in solution get into contact with the capillaries in about one second of time - Now Herring has asserted that the blood circulates through the entire body in half a minute, but others say in two minutes, we may however conclude that substances in solution pass through the entire body in about one, and one and a half minutes -

Blake has shown that it only requires 9 seconds for poison introduced to an absorbing surface to produce death -

Action of Poisons - Enter fully into the subject - An excellent digest of Addison & Morgans experiments will be found in Appletons paper on Toxicology in Todds Cyclop: —

Many substances undergo considerable change by passing through the liver; if bile or atmospheric air be introduced into a vein, the animal dies immediately but if they be introduced into the vena porta so as to pass through the liver, they produce no effect on the animal — Some substances undergo a change in the intestines - thus the poison of the viper produces no poisonous effects when taken into the stomach.

A congested state of the vessels retards absorption — Magendie injected water into the veins & found that it retarded the absorption of foreign bodies - Venesection on the contrary increased absorption —

Absorption by the Skin. Mucous membranes and serous M.es more readily absorb than the skin covered with Epidermis = but there can be no doubt that the skin does possess the power though in a slight degree, and the matters to be absorbed must be either readily soluble in animal fluids or already in a state of solution.

All Metallic substances when rubbed into the skin have the same effect as when given internally,

though in a less degree — Mercury applied in this manner cures syphilis, and excites salivation. Tartar Emetic according to Lebsom and Brera excites vomiting. Arsenic produces its poisonous effects.

Is the skin covered by Epidermis capable of absorbing Water? It is, but the quantity absorbed is small, as shown by the experiments of Dr Madden and M. Berthold. The skin is most extensively supplied with lymphatics however. Muller p 269-270.

Absorption of gases. Many physiologists have observed the absorption of nitrogen by the skin: Beddoes says he saw the arm of a negro become pale when immersed in chlorine. Abernethy held his hands in oxygen, nitrogen and carbonic acid, and other gases contained in jars over mercury, the gases became diminished in quantity.

Interstitial Absorption. It is still uncertain whether this form of absorption is carried on by the capillaries or by the lymphatics — but there are some parts such as bones which are liable to interstitial absorption which have no lymphatics whatever. In the following instances however it is very difficult to determine to which class of vessels we shall refer the phenomena — the reabsorption of the colouring matter of the bile in jaundice — and the re-absorption of accumulated secretions, as bile and urine into the circulation; the wasting of the Thymus gland, during the period from Infancy to the twelfth year; the removal of the Fat, from

fasting; and in animals during hybernation, and the frequent sudden removal of warts.

Interstitial Absorption. What? how distinguished from that of fluids — The most marked example of interstitial absorption, is the removal of the Tail of the Tadpole and the pupillary membrane of the foetus. Müller thinks that such parts must undergo a species of softening in order to get into the condition suitable for removal — Another excellent example of this process, is observed in the formation of the cells of bones — These are formed long after the bone is formed — In old age the Diploe disappears and the bones become thinner, from interstitial absorption. John Bells Insterl Absorption of the head of the Thigh-bone — The Frontal & Sphenoidal Sinuses are developed in the period of ~~growth~~ youth. The Roots of the first teeth disappear at the period of second dentition.

In paralysis too, the muscles are removed by this process and are frequently replaced by a fatty substance of a very yellow colour — vide Cruveilhier — According to Desmoulins & Schroeder, neither cartilage brain, nerves, or bones become atrophied in Phthisis

Pressure is another frequent cause of atrophy — Application of this fact — 1st Bubos, Spica bandage. Pressure on enlarged testicle — Tumours in the breast — Aneurisms by Anastomoses, and many other diseases — It is not very well understood in what manner pressure causes the atrophy of bone.

If by cutting off the nutrition, other parts besides those subjected to pressure should become also atrophied, which is not the case —

Exhalation and Secretion. Many foreign matters which enter the system, are carried off by imbibition and secretion — Prussiate of Potass can be detected in the urine in from 2 to 10 minutes after its introduction into the system.

The gaseous constituents of the Blood unless retained some special attraction exerted on them by the tissues, may evaporate from the free surfaces of the body —

The animal fluids also escape into the cavities usually occupied by gas, when favoured by pressure in obedience to laws purely physical. — Hence the effusion of fluid in the cavities after death, the result of gravitation — serum, sometimes bloody, at other times pure. Bile escapes from the gall-bladder and tinges all the surrounding parts. Pressure on the large venous trunks causes the effusion of serum, not only into the cellular tissue of the parts through which the vein or its branches pass, but also into the Cavities immediately connected with it.

But if the escape of the constituents of the blood were the result of mere physical laws, as imbibition, endosmosis and pressure — How

comes it, that in some cases fibrine is exuded, in others serum - We know that the fibrine is held in solution by the serum, yet when a part becomes inflamed the fibrine is exuded, and in dropsies the serum - Müller avers, "that there must be, under ordinary circumstances, some force in action which prevents the escape of fibrin from the vessels but which in inflammation is rendered inert: and this force must be an affinity or attraction subsisting between the parenchyma and the fibrin, but not between the parenchyma and the albuminous serum, which therefore in anasarca is allowed to escape - At the commencement of inflammation, as observed in a wound, or after the application of a blister serum merely is effused; when the inflammation becomes more violent, the fibrinous part of the blood also exudes" -

Secretion. Endosmosis will not explain the elimination of all the materials of the Blood, Urea has been found already formed in the blood, yet it is only secreted by the Kidneys - Other excretions (as for instance the menstrual fluid) are only secreted at stated periods - According to Muller, Lavagna and Brande this fluid does not contain any fibrin. But Brande is wrong in stating that it is merely

a concentrated solution of the red colouring matter of the Blood. Müller supposes that at the menstrual period the texture of the vessels of the Uterus becomes so loose as to allow of the escape of the red particles —

The Globules of secreted fluids must be formed at the moment of their separation from the Blood, for they could not have passed through the pores of the Vessels —

"The elimination by the Kidneys, of globules of pus which had found their way into the blood, is quite an impossibility: the proximate components only of the pus in a state of solution can be eliminated from the blood, the globules must be formed from these components afterwards." Müller p. 275 —

17

Secretion.

[illegible]

5 July 1857

To illustrate

drawing of Choroid gland of fishes

add 3 pages or so, besides Muellers quotation at page 7.

Secretion. &c. During the passage of blood
through the arterial capillaries to join the venous,
parts of the Liquor Sanguinis with the matters contained
in it, are imbibed by the tissues, and undergo
changes, which have been termed "Metamorphoses".
These are of three Kinds —
1st Transformation of the components of the Blood
latin into the organised substance of the different organs.
Intussusceptio — or nutrition.
2nd Transformation of the components of the blood
on the free surface of an organ into a solid con=
organised substance, which is the mode of growth
of non-vascular textures — Appositio —
3rd Transformation into a fluid substance which
escapes on the free surface of the organ — This is
properly speaking Secretion — { True or secretions proper — as excrements &c —
Matters separated from the Blood are of two classes
those which are excrementitious, and those necessary
for the nourishment & protection of the body —
First. those which already existed, in the same state as
when secreted = such as Urea, Lactic Acid, the latter
of which enters into the composition of the both Urine
and the perspiration. This form of substance has been
denominated Excretions — Berzelius supposed that all
excretions were acid; this is not true, for urine of some
herbivorous animals is alkaline, and the other secretions
of some animals.
The second Form of Secretion. comprises all those substances

which did not exist in their combined form in the blood, pre-
vious to secretion, but whose elements were combined and
arranged by that process, such as the Bile, semen, milk,
mucus. &c. These are true secretions.
These true secretions are also divisible into two classes.
a. Those, which after their formation exercise no other infl-
uence in the animal economy, - and whose formation
was for purposes of defence &c, such as the poison
secretion of serpents - the acrid matter of beetles, wasps
bees and scorpions, the peculiar secretions from the spi-
der - the black secretion from the cuttle fish, the odorif-
erous secretions from musk rat, musk deer, polecat,
skunk, &c. These secretions besides serving as protec-
tion for the animals, may also exercise great influ-
ence on their economy by depriving the blood of some
of its constituents, which enter into new combinations
to form these peculiar secretions, acting in this
manner like the urinary and cutaneous secretions -
b. Other secretions, such as the bile, semen, milk
and mucus, besides acting as the first ones do, by de-
priving the blood of some of its components, also
serve other purposes in the animal economy -.
The secreting organs are of 3 forms 1st either cells,
like those of adipose tissue; 2nd plane membranes,
such as the synovial or serous membranes; or 3rd
organs of peculiar complex arrangement, viz glands -
1. Cells. The clearest example of this form of secretion
is presented in the secretion of fat by the cells of the
adipose

tissue. this substance accumulates in the omentum, around the Kidneys, in the medullary cavities of bones and cells of bones, and in various other parts of the body – It does not require a special structure for its deposition, for it may appear in all parts of the body. It is quite unorganised and at the temperature of the human body is even fluid or soft.

The different kinds of fat are chiefly distinguished by the different degrees of temperature at which they become fluid or soft, and by the different proportions of stearine and elain which they contain. Human fat is very soft –

Use of fat – 1st to fill up cavities, and contribute to the beauty of the figure – 2nd To act as a non-conductor of calorie – 3rd To serve as a storehouse of provisions in cases where ordinary & sufficient nutriment is not taken into the system –

2nd. The principal secreting membranes, are the serous membranes, the mucous membrane and the skin — Serous membranes – Revert to their character – [illegible] the Characters of Mucous membranes – The skin – Allude to its peculiarities and formations – see my former Lectures, & [illegible] p. [illegible] –

3rd Glands as Liver, Kidneys, testicles &c – these present themselves of 2 kinds, either with or without efferent ducts –

The action of the first is to exert a kind of plastic influence on the fluids which circulate through them –

they consist almost wholly of vessels, which undergo the most minute subdivision and then re-unite to form the vasa-efferentia.

This form of glands is divided into those which are principally composed of bloodvessels such as the spleen, the supra-renal Capsules. The thyroid and Thymus glands. The Choroid gland in the eye of fishes, and the Placenta. These glands are sometimes united into one mass as in the spleen and the placenta, at other times they are divided into several masses, as in the case of the Cotyledons and splenculi of some animals.

b the second form. Lymphatic glands. These are formed by branches of the inferent and efferent ducts.

The second class of glands, are those which not only effect a change in the blood in its passage through them, but which form new and important compounds from the elements of the blood.

The use of the thyroid, thymus, supra-renal bodies, are unknown, there are no ducts leading to or from them. Glands are duplications of their ducts, as testicle of vas deferens, liver of its ducts, &c.

Mullers recent investigations into the nature of glands.

The result has been the discovery that the secreting Canals in all glands form an independant system of tubes; that, whether they be convoluted, as in the kidney and testis, or ramified in an arborescent form, as in the liver and salivary glands, — whether they terminate

ly twig-like coeca, as in the liver, or in grape-like clusters of cells, as in the salivary glands, pancreas and mammary gland, — their only connexion with the blood-vessels, in all cases, consists in the latter ramifying and forming a capillary net work on their walls and in their interstices; and that the finest secreting tubes, namely those of the liver and Kidneys, are always several times larger in diameter than the minute ramifications of the arteries and veins.

All secreting glands agree in this, that by the interior of their tubes, or of their convoluted or ramified canals, they afford an extensive surface for secretion; and that the same action is performed by the inner surface of their canals or ducts, as is effected in a more simple manner by a plane secreting membrane.

Of the Causes of Secretion.

Secretion is nothing more than one of the many metamorphoses, through which the blood passes. The capillaries have no open mouths, but their coats are extremely delicate, and allow the free interchange of material between the blood and the substance of the organ. The substance of the organ imbibes the blood and appropriates its components to itself, assimilating them in a different way in each organ.

All Secretions are formed on the Free Surface.

No matter whether they occur on the free surfaces of serous or mucous membranes, or in the complicated structure of glands — it is always on the free surface of the tubes traversing these glands that the secretion

takes place. The minute arteries terminate in the com=mencement of the veins — in this inosculation, the vessels form a most intricate and minute network, some of the constituents of the blood escape, and per=meate the membranous walls of the ducts, where a change, varying with the function of the gland is effected upon them, and a secretion of a nature dif=ferent in each gland, takes place from the free sur=face of the tube —

In this way, the most complicated gland is nothing more or less than an extensive surface, for secretion, but for convenience and compact, its secreting surface is packed up in the smallest space possible.

In short the process of secretion is extremely like that of nutrition — for in both the blood parts with some of its constituents, and circulates in like manner through innumerable minute vessels, but in nutrition the parts taken from the blood, are taken up into the system, but in Secretions the parts taken from the blood, form new combina=tions and are eliminated from the body.

Seat of the Secretion. It was formerly thought that secretion took place only from the extremities of the glandular canals, or in the so called acini. This is however quite incorrect, for it is now found that this process takes place from all parts of the gland and is consequently at work in all parts at the same time —

Exhalation. The older Physiologists maintained this opinion of the existence of Exhalent vessels, but it has now been proved that no such vessels exist, and that the bloodvessels merely form an intimate network, which is extremely superficial in a structure not covered by Epithelium.

The fluid parts of the blood permeate the delicate membrane and escape on its free surface after undergoing a Chemical change.

But why is it that secretions only escape from the free surface of the membrane. Why do they not accumulate under the attached surface?

This Müller acknowledges is one of the most difficult problems in Physiology to solve. He offers the two following hypotheses on the subject.

1st. Here quote from Müller page 509.

Dr Wallaston supposed that secretion was attended with electrical action. His experiment.

A glass tube two inches long, and 3/4 of an inch wide, was closed at one end with bladder, & partly filled with water containing 1/240 of Common salt. The Bladder was moistened on the exterior and placed on a plate of silver; and by the other brought in contact with the water, pure soda appeared on the outer surface of the bladder." Müller p. 510.

<u>Cause of the difference of the Secretions</u> - (It is unaccounted for, why different secretions occur in different organs, as urine in the Kidnies - bile in the liver, &c -) 1st they have been attributed to the difference in the rapidity of the bloods motion in the different organs; but no such difference exists - <u>2nd</u> To different states of the bloodvessels, and to the particular angles at which they divide - but in Lieburkuhns preparations the vessels of the kidney and those of the liver divide in the same way as in those of the testes - 3rd Difference in the free ends of the arteries - all these views are without foundation -

Neither does the peculiarity of the secretion depend upon the anatomical structure of the gland, for secretions of various natures are formed by glands almost identical -

The nature of the secretion depends solely upon the peculiar vital properties of the secreting organ - <u>Chevreul</u> and others have been of late employed in endeavours to prove that the secretions are merely formed by depriving the blood of some of its Constituents which already existed in it - and not by an actual change or re-arrangement of these Constituents. The glands act, merely in attracting from the blood the peculiar matter which it is their office to secrete - Some discoveries of Gmelin tend to throw approbation upon this view - He has found in the blood, a great similarity between the salts

and those of the secretions, namely Casein, cholesterine, Stearine, elain, and elaic Acid, have been discovered in the blood.

Müller thinks this theory very objectionable - for neither horn, mucus, biliary matter, picromel, semen, true casein, true salivary matter, nor the poisonous matters secreted by animals, are contained in the blood - The occasional imbibition of some of the constituents of the secretions into the blood, is no proof of this theory - And even if the components of all the secretions were found in the blood, it is no proof - for the great difficulty would still ~~exist~~ be to account for their getting there - "for instance in the herbivorous animals" -

The Chemical process of secretion is not understood. The great difficulty is to determine, how it is, that the secreting membrane can attract blood, for its own nourishment, and from exactly similar blood, derive secretions, or excretions which may be non-analagous -

The Elementary parts of a secreting fluid are either of grey, greyish white, or yellowish white colour - The constituents of the urine cannot be found in the kidney nor can those of the Bile be detected in the Liver - excepting the fatty matter, which in disease accumulates to a great degree -

Influence of the Nerves upon Secretion - Baron Von Humboldt

applied a blister over each shoulder - he covered one of the blistered surfaces with a silver plate, and closed the circle by means of a conductor of zinc, when a painful burning was produced and a change in the character of the discharge; from being bland and colourless, it became a red and acrid fluid - leaving livid red streaks on the parts of the back where it ran -

M. Mast found, that on causing a galvanic current to pass through the parotid, by applying the positive pole to the situation of the gland for the space of ten minutes, that while he held the negative pole in his hand, an increased secretion of saliva, which was neither acid nor alkaline took place.

After division of the nervus vagus, the secretion of the gastric juice ceases, not always so, as proved by Muller and Dieckhof - and Dr Reid -

Sir B. Brodie, showed that when the 8th pair was divided, that there was not the profuse secretion in the stomach which takes place usually when arsenic is administered. This is not corroborated by Dr Reid, he found the secretions as abundant or nearly so, as when the nerve was left uncut.

Secretion of pulmonary mucus of a bloody nature is greatly increased by division of the eighth pair -

Dr Kremer has found that limpid urine is generally present in nervous diseases, (in Hysteria) urine is deficient

f urea)- And after dividing the nerves of the Kidney,
he has found it to contain "albumen and blood,
their proportion increasing in the same proportion as
that of the urine diminished. Division of the Vagus
did not put a stop to the secretion of the urine, but
Rhubarb and Prussiate of Potash could not be detec-
ted in that secretion, which increased in specific
gravity, from containing the serum of the blood".
When the divided nerves were connected by means of
the galvanic pile, the urine regained its usual
character —
Bruschet's experiments. He divided the renal artery of a
dog, and then connected its two portions by means of a
cannula, so that the renal nerves were divided, but the
supply of blood maintained. The fluid which flowed from
the ureter during several hours after, was red, and
separated into a fibrous coagulum and serum.
Repetition of the experiment was attended with the
same result. Division of the nervi vagi had no
effect on the secretion of urine.
Müller and Dr Peipers applied a ligature to the
renal vessels of dogs and sheep (the ureter being
excluded) and tied it so tightly that the texture of
the renal nerves included in it at that point should be
destroyed. The ligature was again loosened, and the
circulation of the blood thro' kidney re-established.
The ureter was brought to the exterior of the body and
a tube connected with it. In most cases the

secretion of urine was completely arrested -

Influence of nervous impressions on glands may be of a different nature in each gland, or which is more prob= able, it may be the same in all, merely enabling the secreting substance, in each gland endowed with pecu= liar properties, to exert its chemical action. Daily experience affords us many proofs of the influence of the nerves on secretion. During the depression of the ner= vous system in the cold stage of fever, the quantity of the secretions and the proportion of their ingredients are diminished; with the accession of the hot stage, the secretions are restored. The influence of passions of the mind on secretions, for example, on the secretion of the tears, the bile, the milk, secretion from wounds, &c.

In hemiplegia from disease of brain or spinal mar row, the secretion of the surface on affected side, in some cases is altered, in others remains unchanged -

Changes of which the Secretions are Susceptible -

The process may be disturbed from local and consti= tutional causes.

Stimulants or irritation, at first increase the secretion in quantity, but as the irritation passes into inflam= mation it proportionably diminishes -

Interruption of nervous influence causes diminution in quantity in the secretion of an organ; thus in hysteria urine is colourless; in fevers with depressed nervous

* action of the abdominal muscles, while the mouth of the duct is open. Muller doubts if the gall bladder is contractile.

The nature of the internal coat of the efferent ducts, and the contractility of the middle coats, prove most clearly that they are merely diverticula of the membranous tubes into which they lead; thus the ductus choledicus and pancreaticus, consisting as they do of the same membranes as the duodenum, are prolongations of its coats - Muller 521

nergy, & in cold stage of all fevers, the skin is dry.

<u>Antagonism of the Secretions</u>. Effusion of watery fluids into the cellular membrane and serous cavities is attended with dryness of the skin and diminution of urine, the quantity of which increases in proportion as the dropsical effusions diminish. Suppression of exhalation from the skin by cold; gives rise to mucous discharges from the intestinal and pulmonary mucous membranes.

Sometimes the suppression of a secretion in one part of the body gives rise to the appearance of the same fluid in another. Effusions of blood vicarious of the menstrual flux, have certainly occurred; and the total destruction of both kidneys, by preventing the elimination of the urea in the blood, induces effusions of fluid impregnated with urea in all the other parts of the body.

<u>Discharge of the Secretions</u>, & Anatomical peculiarities of the Efferent Ducts.

The <u>efferent ducts</u> of glands are lined by a mucous membrane, which has on its exterior an <u>extremely</u> thin layer of muscular substance. The existence of these muscular fibres is now placed beyond dispute; the efferent ducts of most glands have the power of contracting when irritated.

The discharge of the bile from the gall bladder during digestion results probably from the mere pressure of the surrounding parts, and the *,

18

Respiration No 1.

J D Gibb M.D.

8th July 1851

To illustrate

Capillaries of Lung in Carpenter.
2 drawings on large paper. p 150 Kirkes
Cloquets plate of bronchial tubes.

Respiration - As the blood circulates through the various parts of the body, it is deprived of part of its nutritive constituents, and becomes charged with impurities resulting from the deterioration of the tissues. It is, therefore, necessary that fresh supplies of nutriment should be continually added to the blood, and that provision should be made for the removal of the impurities. The first of these objects is accomplished by the processes of digestion and absorption. The second is principally effected by the agency of the various excretory organs through which are removed the several impurities with which the blood is charged, whether these impurities are derived altogether from the degeneration of tissues, or in part, also, from the elements of unassimilated food. One of the most important and abundant of the impurities is carbonic acid, the removal of which, and the introduction of fresh quantities of oxygen, constitute the chief purpose of respiration. Structure of the Lungs:-

As the digestive organs vary, so do the respiratory in the lower orders of creation. In the Infusaria the only respiratory organs seem to be delicate cilia. Among the Mollusca some breathe in water by means of branchiae, others by lungs in the air. The Crustacea also breathe by branchiae. Lungs are unnecessary in fishes

Minute Anatomy of Lungs - Respiration

see article Emphysema in Vol 2 of Cycl. Pract. Med. page 23 - copy 34 lines -

and aquatic animals, gills answering the purpose, each carrying an afferent and an efferent capillary vessel. In Reptiles there is the first attempt, at the formation of a regular lung; and the air cells are very large; in them it is called a rare lung.

In Birds the cells are very small and minute and form what is called a dense lung. In one form of emphysema, the vesicles become diseased and resemble the permanent condition of the lower orders. In addition to lungs in birds, we find air sacs large, communicating with them, dispersed in different parts of the body, extending even into the bones, thus presenting a large respiratory surface.

In Man and the Mammalia the lungs are the same, presenting a large tube like a stalk, and a number of its divisions, resembling a bunch of grapes. The lungs are divided into cavities of extreme minuteness; so that the extent of surface which they expose is enormously increased. These cavities or air cells, are all connected with the trachea, by means of the bronchial tubes and their minute subdivisions. (Cloquets Plate)

The bronchial tube belonging to each lung passes into its substance, dividing and subdividing, but without anastomosis, and sending branches to every part of the organ. All the larger branches have walls formed of tough membrane with organic-muscular circular fibres, giving them

some power of spontaneous contraction; portions
of cartilaginous rings by which they they are held
open, and longitudinal bundles of elastic tissue,
for greater power of recoil after extension:
they are lined with mucous membrane, the sur=
face of which is covered with vibratile ciliary
epithelium. But when the bronchi, by successive
branchings, are reduced to about $\frac{1}{100}$ of an inch
in diameter, they lose these structures, and their
walls are formed of only a tough, elastic mem=
brane, with traces of fibrous, perhaps muscular
structure, over which the capillaries are spread
in a very dense network, and on various parts
of which air-cells irregularly open. Tubes of this
kind are named by Mr Rainey, intercellular passages.

The air-cells opening into them may be placed singly
in their walls, like recesses from them; but more
often are arranged in rows like minute saccula=
ted tubes: so that a succession or series of cells,
all opening into one another, open by a common
orifice into the tube. The cells are of various
forms, according to the mutual pressure to which
they are subject; their walls are nearly in con=
tact, and they vary from $\frac{1}{120}$ to $\frac{1}{1200}$ of an
inch in diameter.+ Their walls are formed of
fine membrane similar to that of the intercel
lular passages, and continuous with it, which
is folded on itself so as to form a sharp-edged

+ See [illegible] in Appendix   + [illegible] - pp 47. 48

border at each circular orifice of communication between contiguous air-cells, or between the cells and the bronchial passages.

The cells have no epithelial lining; but on the exterior of the membrane of which they are constructed, a network of pulmonary capillaries is spread out so densely that the interspaces or meshes are even narrower than the vessels, which are, on an average, $\frac{1}{3000}$ of an inch in diameter. Figure 4 of Bennett. 182 Carpenter's Manual.

Between the atmospheric air in the cells and the blood in these vessels nothing intervenes but the thin membranes of the cells and capillaries; and the exposure of the blood to the air is the more complete because the folds of membrane between contiguous cells, and, often, the spaces between the walls of the same, contain only a single layer of capillaries, both sides of which are thus at once exposed to the air.

The cells situated nearest to the centre of the lung are smaller, and their networks of capillaries are closer, than those nearer to the circumference, so as to furnish a more ready supply of fresh air to the central than the peripheral portion of the lungs. The cells of adjacent lobules do not communicate; and those of the same lobule, or proceeding from the same intercellular passage, do so as a general rule only near angles of bifurcation;

-y that; when any bronchial tube is closed or obstruc-ted, the supply of air is lost for all the cells opening into it or its branches.

Respiratory Movements — The dilatation of the cavity of the chest, which constitutes Inspiration, is accomplished by two sets of movements; — the elevation of the ribs; — and the depression of the diaphragm. From the peculiar mode in which the ribs are articulated with the spinal column at one extremity, and from the angle which they make with the cartilages ~~at the~~ that connect them to the sternum at the other, the act of elevation tends to bring the ribs and the cartilages more into a straight line, and to carry the former to a greater distance from the median plane of the body, whilst the sternum is also thrown forwards. Consequently the elevation of the ribs increases the capacity of the thorax, upwards forwards and laterally. The movement is chiefly ac-complished by the Scaleni muscles which draw up the first rib; and by the Intercostals, which draw the other ribs into nearer proximity with each other, so that the total amount of movement in each rib in-creases as we pass from above downwards, — every one being drawn up by its connection with the one above it and being drawn nearer to it by the action of its own intercostals. The elevation of the ribs is further assisted by the Serratus magnus, and by other muscles connected with the spine and the scapula; and when the respiratory movement is very forcibly performed the scapula is itself drawn upwards, by the muscles that descend to it, from the

neck, thus producing an increased elevation of the ribs, and an unusual enlargement of the upper part of the thoracic cavity. — When the respiratory action is to be performed, the descent of the ribs is occasioned by the muscles of the spine and abdomen, which proceed upwards from the lower part of the trunk; and this action is aided by the elasticity of the costal cartilages.

In the ordinary act of inspiration, however, the Diaphragm performs the most important part. The contraction of this muscle changes its upper surface, from the high arch that it forms when relaxed and pushed upwards by the viscera below, to a much more level state; though it never approaches very closely to a plane; being somewhat convex, even when the fullest inspiration has been taken. When thus drawn down, it presses upon the abdominal viscera, and causes them to project forwards, which they are allowed to do, by the relaxation of the abdominal muscles. In tranquil breathing, this action is alone nearly sufficient to produce the requisite enlargement of the thoracic cavity; the position of the ribs being very little altered. In the expiratory movement, the diaphragm is altogether passive; for, being in a state of relaxation, it is forced upwards by the abdominal viscera, which are pressed inwards by the contraction of the abdominal muscles. These last, therefore, are the main instruments of the expiratory movement, diminishing the cavity of the chest by elevating its floor, at the same time that they draw its bony framework into a narrower compass.

2

Fig 10 (man) The charges of the thoracic & abdom walls of the male during Expiration. The back is supposed to be fixed in order to throw forward the resp^y movement as much as possible. The outer black continuous line in front represents the ordinary breathing movement: the anterior margin of it being the boundary of inspiration, the posterior margin the limit of expiration. The line is thicker over the abdomen, since the ordinary respiratory movement is chiefly abdominal: thin over the chest, for there is less movement over that region. The red line indicates the movement on deep inspiration, during which the sternum advances while the abdomen recedes.

Fig 11 (Female) The respiratory movements in the female. The lines indicate the same changes as in last figure. The thickness of the continuous line over the sternum shows the larger extent of the ordinary breathing movement over that region in the female than in the male —

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In young children the inspiration is effected almost entirely by the diaphragm.

In adult men, together with the descent of the diaphragm, and the pushing forward of the front wall of the abdomen, the lower part of the chest and the sternum are subject to a wide movement in inspiration. In women, the movement appears less extensive in the lower, and more so in the upper, part of the chest; a mode of breathing to which a greater mobility of the first rib is adapted, and which may have for its object the provision of sufficient space for respiration when the lower part of the chest is encroached upon by the pregnant uterus. M.M. Beau and Maissiat call the former the inferior costal, and the latter the superior costal, type of respiration; but the diagrams from Mr Hutchinsons paper will explain the difference better than the names, which imply a greater diversity than naturally exists in the modes of inspiration. (show them, &c)

By the regularly-alternating dilatation and contraction of the thoracic cavity, the air within the lungs is alternately increased and diminished in amount; and thus a regular exchange is secured. This exchange, however, can only affect at any one time a certain proportion of the air in the lungs; thus it is probable, that the quantity remaining in these organs after ordinary expiration is above 100 cubic inches, whilst the amount usually expired is not above 20 cubic inches. Indeed if it were not for the tendency of gases to mutual diffusion, the air in the

-mate cells-air might never be renewed. — If any aper=
-ture exist, by which air could obtain direct access to
the pleural cavity, the lungs would not be dilated by its
enlargement; for the vacuum would be supplied much
more readily, by the direct ingress of the air (provided
the aperture be large enough), than by the distention
of the lung. Thus a large penetrating wound of the
thoracic cavity may completely throw out of use the
lung of that side; and the same result will follow,
when an aperture forms by ulceration in the substance
of the lung itself, establishing a free communication
between the pleural cavity and one of the bronchial
tubes; so that, of the air which rushes in by the
trachea, to compensate for the enlargement of the
thoracic cavity, a great part goes at once into that
cavity, without contributing to the distension of the
lungs, and therefore without serving for the aeration
of the blood.

Number of Respiratory Movements. — The number of the
respiratory movements (that is, of the acts of inspiration
and expiration taken together) may be probably
estimated at from 14 to 18 per minute, in a state
of health, and of repose of body and mind. Of these,
the greater part are moderate in amount, involving
little movement except in the diaphragm; but a
greater exertion, attended with a decided elevation
of the ribs, is usually made at every fifth recurrence.
The frequency of the respiratory movements, however,

is liable to be greatly increased by various causes, such as violent muscular exertion, mental emotion, or quickened circulation; whilst it may be diminished by torpidity of the nervous centres, on which the movement depends, — as we see in apoplexy, narcotic poisoning, &c. An acceleration seems very constantly to take place in diseases, which unfit a part of the lung for the performance of its function; and the rate bears a proportion to the amount thus thrown out of use. Thus, the usual proportion between the respiratory movements and the pulse being as 1 to 4½ or 5, it may become in Pneumonia as 1 to 3, or even in severe cases as 1 to 2; the increase in the number of respiratory movements being much greater in proportion, than the augmentation of the rate of the pulse. But it must be remembered by the practitioner, that a simply hysterical state may produce, in young females, an extraordinary acceleration of the Respiration; the number of movements being sometimes no less than 100 per minute.

According to Mr Hutchinson the force with which the inspiratory muscles is capable of acting is greatest in individuals of the height of from 5 feet 7 inches, to 5 feet 8 inches, and will elevate a column of 3 inches of mercury. Above this height, the force decreases as the stature increases; so that the average of men of six feet, can elevate only about 2 and a half inches of mercury.

The force manifested in the strongest expiratory act is, on the average, one-third greater, than that exercised in inspiration. But this difference is in great measure due to the power exerted by the elastic reaction of the walls of the chest; and it is also much influenced by the disproportionate strength which the expiratory muscles attain, through being called into use for other purposes than that of simple expiration. The force of the inspiratory act is, therefore, better adapted than that of the expiratory for testing the muscular strength of the body.

The muscular action in the lungs, morbidly excited is probably the chief cause of the phenomena of spasmodic ~~action~~ asthma. It may be demonstrated by galvanising the lungs shortly after taking them from the body: under such a stimulus, they contract according to Dr Williams, so as to lift up water placed in a tube introduced into the trachea; and Volkmann has shown that they may be made to contract by stimulating their nerves. He tied a glass tube, drawn fine at one end, into the trachea of a beheaded animal, and when the small end was turned to the flame of a candle, he galvanised the pneumogastric trunk: each time he did so, the flame was blown, and once it was blown out.

But for the tendency of the oxygen and carbonic

-ied to mix uniformly, within and without the lungs, the reserve and residual air would, probably, be very injuriously charged with carbonic acid; for the respiratory movements alone are not enough to empty the air-cells, and perhaps expel only the air which lies in the larger bronchial tubes. Probably also the change is assisted by the different temperature of the air within and without the lungs; and by the action of the ciliae on the mucous membrane of the bronchial tubes, the continual vibration of which may serve to prevent the adhesion of the air to the moist surface of the membrane.

Movement of the Blood in the Respiratory Organs - To meet the air thus alternately moved into and out of the air cells and minute bronchial tubes, the blood is propelled from the right ventricle through the pulmonary capillaries in steady streams, and slowly enough to permit every minute portion of it to be for a few seconds exposed to the air, with only the thin walls of the capillary vessels and air-cells intervening. The pulmonary circulation is of the simplest kind; for the pulmonary artery branches regularly; its successive branches run in straight lines, and do not anastomose; the capillary plexus is

uniformly spread over the air-cells and intercellular passages; and the veins derived from it proceed in a course as simple and uniform as that of the arteries, their branches converging but not anastomosing. The veins have no valves, or only small imperfect ones prolonged from their angles of junction, and incapable of closing the orifice of either of the veins between which they are placed.

The pulmonary circulation also is unaffected by changes of atmospheric pressure, and is not exposed to the influence of the pressure of muscles: the force by which it is accomplished, and the course of the blood, are alike simple.

The blood carried through the pulmonary artery, being venous till it comes to the capillaries, is unfit for the nutrition of any part of the lungs, except those in which it flows through the capillaries: to these it probably supplies nutritive materials as soon as it is itself arterialised. For the nutrition of the rest of the lungs, including the pleura, interlobular tissue, bronchial tubes and glands, and the walls of the larger bloodvessels, a special supply of arterial blood is furnished through one or two bronchial arteries, the branches of which ramify in all these parts.

The blood of the bronchial artery when, having served for the nutrition of these parts, it has become venous, is carried, partly, into the branches of a bronchial vein, distributed in the parts about the root of the lung; and partly into the small branches of the pulmonary artery, or, more directly, into the pulmonary capillaries, whence, being with the rest of the blood arterialized, it is carried to the pulmonary veins and left side of the heart.

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Respiration No 2.

G D Gibb M D

9th July 1857

add 3 pages —

Respiration Continued = Lecture No 2 -

Chemical Phenomena of Respiration.

Changes of the Air in Respiration -

The atmosphere contains about 21 per cent of Oxygen to 79 of Nitrogen, by measure; or 23 parts of Oxygen to 77 of Nitrogen by weight - The Nitrogen seems to perform no other part, than that of diluting the oxygen; at least the results of the most recent and exact experiments render it very doubtful, whether (in the respiration of Man at least) any change is effected in the Nitrogen of the inspired air. The leading phenomena of respiration, is the removal of a certain quantity of Oxygen from the air, and its replacement by carbonic acid. The relative proportions, which the oxygen absorbed, and the carbonic acid exhaled, bear to one another, have been variously estimated. The most recent and trustworthy experiments on this subject, are those of Brunner and Valentin, and lead to a very interesting result.

According to the law of the "mutual diffusion" of gases, the volumes of any two gases, that pass through a porous medium to mingle with each other will be respectively in the inverse proportion to the square roots of their specific gravities. Now when Oxygen is on the outer side and Carbonic acid on the inner, the volume of Oxygen that passes inwards will exceed that of the Carbonic acid that passes outwards; and this in the

proportion of 1174 to 1000. This calculation, deduced from the relative densities of the two gases, corresponds so closely with the actual result of experiments upon the respiration of Man, that it seems next to certain, that the interchange of oxygen and carbonic acid, which occurs between the air and the blood in the lungs, takes place in exact accordance with this law of mutual diffusion.

Now Carbonic Acid contains precisely its own volume of oxygen; consequently, of the 1174 parts of oxygen absorbed, 1000 are excreted again by the lungs in the form of carbonic acid; and there remain 174, or nearly 15 per cent, to be accounted for in other ways. It is certain that some of this enters into combination with the sulphur and phosphorus of the original components of the body; and converts these into sulphuric and phosphoric acids; and the remainder must enter into other chemical combinations, very probably uniting with the hydrogen of the fatty matter, to form part of the water, which is exhaled from the lungs.

It is difficult to form an exact estimate of the actual quantity of Carbon, thrown off from the lungs in the form of Carbonic acid during any lengthened period; since the amount disengaged during experiments carried on for a limited time, cannot, for many reasons, be taken as affording a fair average. Thus the quantity will vary with the external temperature, with the state of previous rest or

ctivity, with the length of time that has elapsed since a meal, and particularly with the general developement of the body. The amount of carbonic acid exhaled is greatly increased by external cold; as is shewn in ~~such~~ the results of such experiments as the following. Small Birds and Mammals having been enclosed in limited quantity of air, for the space of an hour, at ordinary temperatures, the quantity of carbonic acid they produced was noted. The experiment was then repeated at a temperature nearly approaching that of the body; and was performed ~~at~~ a third time at a temperature of about 32°. The following are the comparative amounts.

	Temp 59–68° – Grammes.	Temp 86–106° – Grammes.	Temp about 32° Grammes.
A Canary	0.250	0.129	0.325
A Turtle-dove	0.684	0.366	0.974
Two Mice	0.498	0.268	0.531
A Guinea-pig	2.080	1.453	3.006

Thus it would appear that the quantity of carbonic acid exhaled between 86° and 106° is not much more than half of that which is exhaled between 59° and 68°; and is only about two-fifths of that which is given off at 32°.

The quantity of carbonic acid exhaled during exercise, and for a certain time after it, and also after a full meal, is considerably increased; whilst on the other hand, it is greatly diminished during sleep.

thus a person who was excreting 145 grains of carbon per [h]our, whilst fasting and at rest, excreted 165 after din=[n]er, and 190 after breakfast and a walk; whilst he [o]nly excreted 100 during sleep. The variation with the [g]eneral developement of the body, and also with the [s]ex and age, is considerable. Thus, the exhalation is [a]lmost always greater in males, than in females of [t]he same age, at every period of life except childhood. [I]n males, the quantity increases regularly from 8 to 30 [y]ears of age, remaining nearly stationary until 40; – [t]hus it averages 77.5 grains of carbon per hour at [8] years; 135 grains at 15; 176.7 grains at 20; and [1]89 grains between 30 and 40. Between 40 and 50, [t]here is a well marked diminution, the average being then [1]56 grains; and the diminution continues up to extreme [o]ld age, when the amount exhaled scarcely exceeds [t]hat which is extricated at 10 years of age; thus, be=[tw]een 60 and 80, it was 142.5 grains; and in a man [o]f 102, it was only 91.5 grains. (Carpenters Manual)

In females a proportional increase goes on, up [t]o the time of puberty; when the quantity abruptly [c]eases to increase; and remains stationary so long as [m]enstruation continues regular. The average quantity [o]f carbonic acid exhaled by girls nearly approaching [p]uberty, is about 100 grains per hour; and it remains [a]t this standard until nearly the close of menstrual [l]ife. At the period of the cessation of the catamenia,

it undergoes a perceptible increase; the average, between 40 and 50 years of age, being about 130 grains per hour; and the quantity exhaled in a woman of great muscular developement, and of 44 years of age, rising to 152.4 grains in an hour. After the age of 50, or thereabouts, the quantity decreases, as in men. It is remarkable that, during pregnancy, there is the same increase in the exhalation of carbon, as there is after the final cessation of the Catamenia; and the same takes place, if the menstrual discharge be temporarily suspended, through any other cause.

Of the total amount of carbon excreted in a gaseous form, a certain part is undoubtedly set free from the skin; and the proportion of this has not been yet determined.

Professor Liebig endeavoured to ascertain the total amount of carbon excreted from the body in the form of carbonic acid, by comparing the amount of carbon taken in as food, with that contained in the faeces and urine; the difference being set down to the account of respiration. His estimate amounts to the very large sum of 13.9 oz of solid carbon per day, which he considers to be thus set free by the lungs and the skin; but this is almost certainly above the truth. The observations were made upon a body of soldiers, who were subjected to severe daily exertion; and they were far from being exactly conducted, many of the items being set down by guess only, whilst of others

no account whatever was taken. We may perhaps consider 10 or 11 oz as more nearly representing the amount of carbon consumed by adult men exposed to severe exertion; whilst from Professor Scharlings experiments it may be inferred, that from 7 to 8 oz of carbon are thrown off during the 24 hours, by the lungs and skin of adult men not using much active exertion; to which another ounce or two may be added, as the increased quantity excreted during moderate exercise. On the other hand, from experiments made upon the quantity of carbonic acid exhaled from the lungs alone during a given time, it would appear that the pulmonary excretion of carbon amounts to between 5½ and 8 oz in the 24 hours; and the difference may be fairly set down to the account of the cutaneous respiration.

An impregnation of carbonic acid, to the amount of 7 or 8 per cent, would be required to destroy life in most warm-blooded animals, yet a much smaller proportion is sufficient to produce very injurious results. Thus the discomforts occasioned by the presence of a crowded audience in a church, lecture-room, or theatre, which is not provided with sufficient ventilation, are due in great part to the continued respiration of air, which becomes loaded in the course of an hour or two with carbonic acid gas, to the amount of from one half to two per cent, — as has been ascertained both by direct experiment, and by calculation. And there can be little doubt,

hat the habitual respiration of such air, in the narrow
nd noisome dwellings of the poor, or in crowded
actories and workshops, has a tendency to produce,
oth directly and indirectly, much loss of physical
nd mental vigour, and also to blunt the acuteness
f the moral feelings.

Changes produced in the Blood in Respiration -
he most obvious change which the blood undergoes
n its passage through the lungs is that of colour.
he dark crimson of venous blood being exchan-
ged for the bright scarlet of arterial blood.
The change in colour is, indeed, the most striking,
nd may appear the most important, which the
blood undergoes in its passage through the lungs;
et, perhaps, its importance is very little, except in so
far as it is an indication of other and essential
alterations effected in the composition of the blood.
Of these alterations the principal are, 1st that the
blood after passing through the lungs is 1° or 2° warmer
than it was before; 2d that it coagulates sooner and
more firmly, and contains, apparently more fibrine.
3rd that it contains more oxygen, less carbonic acid
and less nitrogen.

If venous blood is agitated in a vial with oxygen
it will become red; the same done with arterial blood
and carbonic acid will turn it blue -

The existence of carbonic acid in both arterial and
venous blood has been proved by several experimenters,
who have obtained appreciable quantities of it by
exposing

the blood to the vacuum of the air-pump, or, more certainly, by agitating it with atmospheric air, oxygen, or other gases, such as hydrogen or nitrogen. By the latter process carbonic acid may always be extracted from venous blood.

The following table expresses the per centage of each kind of gas in the two sorts of blood respectively; as deduced from the experiments of Magnus.

	Arterial Blood	Venous Blood
Carbonic Acid ——	62.3 ——	71.6
Oxygen ——	23.2 ——	15.3
Nitrogen ——	14.5 ——	13.1

Thus it appears that the quantity of nitrogen is very nearly the same in both; whilst about one third of the free oxygen of arterial-blood disappears during its circulation in the systemic capillaries, to be replaced by an equivalent amount of carbonic acid; and a converse change takes place in the pulmonary capillaries, this additional portion of free carbonic acid being set free, and replaced by oxygen.

It is tolerably certain; — that a part of the oxygen imbibed in the lungs, is appropriated to the oxidation of the matters set free by the decomposition of the solid tissues; — whilst another part enters into combination with fatty, saccharine, or farinaceous matters, existing in the blood itself and destined to be carried off in the form of carbonic acid and water, without ever entering into the composition of the solid fabric.

The blood parts in the lungs with a very large

amount of moisture; for the inspired air is always saturated with fluid, as soon as it reaches the air cells; and, as it is heated at the same time to about 98°; it thus receives a considerable addition, even if it were previously charged with as much as it could contain at a lower temperature. The total quantity of fluid thus disengaged will vary, therefore, with the amount previously contained in the atmosphere; being greater as this was less, and vice versâ; the expired air being always charged with as much as it can contain at the temperature of 98° or 99°. It cannot be doubted, that a great part of this water is a simple exhalation of that which has been absorbed; but, on the other hand, it seems probable that a portion of it may be actually formed in the system, by a union of a portion of the oxygen absorbed in the lungs, with the hydrogen of the combustible matters of the blood. In the various forms of saccharine and farinaceous aliments, the proportions of hydrogen and oxygen are such as would themselves form water, when the carbon is withdrawn: but in oily and fatty matters, the proportion of oxygen is far too small, thus to neutralize the hydrogen; and it seems likely that, by their oxidation in the blood, as by their combustion elsewhere, water is actually generated by the union of atmospheric oxygen with their hydrogen, whilst carbonic acid is produced by its union with their carbon.

Along with the water thus extricated from the lungs a certain amount of organic matter is set free. If the fluid be collected in a closed vessel, and be exposed

warmth, a very evident putrid odour is exhaled from it; and if the expired air be made to pass through sulphuric acid, that liquid is coloured red. Every one knows that the breath itself possesses, occasionally in some persons, and constantly in others, a fetid taint; when this does not proceed from carious teeth, ulcerations in the air-passages or lungs, or other similar causes, it must result from the excretion of the odorous matter, in combination with watery vapour, from the pulmonary surface. That this is the true account of it seems evident, from the analogous phenomenon of the exhalation of turpentine, camphor, alcohol, garlic, onions, copaibae, and other odorous substances, which have been introduced into the venous system, either by natural absorption, or by direct injection; and also from the suddenness with which the odour manifests itself, when the digestive apparatus is slightly disordered.

Influence of Nervous System in Respiration -

The respiratory functions are in two respects subject to the influence of the nervous system: namely

1st in the movements for the introduction & exit of air;

2nd ly, in the interchange of the gases.

These I may particularly consider when I come to the Physiology of the Nervous System, especially the medulla oblongata and Pneumogastric nerves.

It will suffice to state for the present, that the respiratory movements and their regular rythm, so far as they are involuntary and independant of

consciousness (as in all ordinary occasions they are), are under the absolute governance of the medulla oblongata, which, as a nervous centre, receives the impression of the "necessity of breathing", and reflects it to the phrenic and such other motor nerves as will bring into coordinate and adapted action the muscles necessary to inspiration.

But the respiratory movements may be voluntarily performed or variously directed, and the mind may be conscious of the necessity of breathing, either when it attends to the sensations to which that necessity gives rise, or when those sensations are more than commonly intense. In these cases, we may believe that the brain, as well as the medulla oblongata, is engaged in the process; for we have no evidence of the mind exercising either perception or will through any other organ than the brain. But even when the brain is thus in action, it appears to be the medulla oblongata which combines the several respiratory muscles to act together. In such acts, for example, as those of coughing and sneezing, the mind must first perceive the irritation at the larynx or nose, and exercise a certain degree of will in determining the actions, as, e.g. in the taking of the deep inspiration that always precedes them. But the mode in which the acts are performed, and the combination of muscles to effect them, are determined by the medulla oblongata, independant of the will, and hence the

peculiar character of reflex involuntary movements, in being always, and without practice or experience, precisely adapted to the end or purpose.

Effects of the Suspension & Arrest of Respiration -

The state which is induced by the entire suspension of the aerating process, is termed Asphyxia; a word which literally means the absence of pulse, and would be applicable therefore to the stoppage of the circulation from any cause; though it is usually employed to designate the particular condition, resulting from suspended respiration. Asphyxia may be produced in aquatic animals, as well as in those which breathe air, by cutting them off from the influence of the atmosphere; for if a Fish is placed in water from which the air has been expelled by boiling, it is precisely in the condition of an air-breathing animal placed in a vacuum, since it has no power of obtaining oxygen by decomposing the water it inhabits, and is entirely dependant for the aeration of its blood, upon the air that is absorbed by the liquid. Again, if a fish be placed in water impregnated with Carbonic acid, its death is nearly as instantaneous as that of an air-breathing animal immersed in an atmosphere of that gas.

Asphyxia may result from a variety of causes, thus there may be a mechanical obstruction to the entrance of air through the trachea; as in hanging, strangulation, or drowning; or as in occlusion of the aperture of the glottis: by oedema of its lips, or by the

presence of a foreign body in the trachea. Or again, the passage may be perfectly free, and yet no air may enter, in consequence of some obstacle to the performance of the respiratory function or movements. This obstacle may be mechanical, as when a quantity of earth has fallen round the body, in such a manner as completely to prevent the distension of the chest and abdomen. Or it may result (and this is a most frequent occurrence) from torpidity or complete inactivity of the ganglionic centre, which is concerned in the respiratory actions; or from interruption to the transmission of its influence along the nervous trunks.

see page 14 -

~~eculiar character of Reflex involuntary movements oi~~
~~ing always, and without practice or experience,~~
~~ecisely adapted to the end or purpose.~~

ffects of the Suspension & Arrest of Respiration.

When the process of respiration is stopped, the circu
tion of blood through the lungs is retarded, and
length stopped. The immediate effect of this is
obstruction to the exit of blood from the right
ntricle: this is followed by delay in the return
venous blood to the heart; and to this succeeds
venous congestion of the nervous centres and all
other organs of the body. In such retardation
so, an unusually small supply of blood is
ansmitted through the lungs to the left side of
heart; and this small quantity is venous.

The condition then, in which a suffocated animal
ies is, commonly, that the left side of the heart
nearly empty, while the lungs, right side of the
art, and other organs are gorged with venous
lood. To this condition many things contribute.
t the obstructed passage of blood through the lungs, which
pears to be the first of the events leading to suffoca
ion, seems to depend on the cessation of the interchange
gases, as if blood charged with carbonic acid
uld not pass freely through the pulmonary capilla=
ies. That such may be the case, is shown by Mr
harton Jones observations that the circulation in
web of the frogs foot may be retarded or ar=
sted by directing on the web a stream of carbonic

-cid, under the influence of which the blood-corpuscles appear to stagnate and cluster in the vessels. But the stagnation of blood in the pulmonary capillaries would not be enough to stop the circulation, unless the action of the heart were also weakened, for Mr Erichsen having pithed dogs, and tied the right bronchus, and maintained artificial respiration in the left lung, found that, so long as the hearts action continued, nearly as much blood flowed through a right pulmonary vein, as red blood through a left one.

Therefore 2ndly, the fatal result is due, in some measure, to the weakened action of the right side of the heart, in consequence, probably, of its over-distension by blood continually flowing into it, which it is not able to discharge quickly through the lungs.

Thirdly, because of the obstruction at the right side of the heart, there must be venous congestion in the medulla oblongata and nervous centres; and this evil is augmented by the left ventricle receiving and propelling none but venous blood.

Hence slowness and disorder of the respiratory movements and the movements of the heart may be added.

But this alone does not explain asphyxia, for Mr Erichsen found that a dog was asphyxiated in the ordinary time, although arterial blood was made to circulate through the nervous centres the whole time. However under all these conditions combined, the heart at length ceases to act.

Thus deficient respiration has an undoubted tendency to produce, in some persons, what is termed "fatty degeneration" of the liver; the fatty matter, which ought to be eliminated by the respiratory process, being thrown upon the liver to be separated by it, and distending its cells. And there is reason to believe, that a similar cause may produce fatty degeneration of the kidney, in cases where there is peculiar determination of blood to that organ.

20_

Animal Heat_

J D Gibb M.D.

15 July 1851

To illustrate

Temp of Mammalia and Birds.
Tidemanns 2 Tables, p 80 & 81 of Muller

add 2 pages more.

Animal Heat - or Temperature.

One of the most remarkable circumstances which distinguishes the living body from dead matter, is the power which it possesses of resisting to a certain extent, the changes of external temperature, and maintaining a uniform degree of heat.

This power is not enjoyed in an equal degree by all animals. Cold blooded and warm blooded.

Warm blooded includes, the human species, mammalia and birds. Cold blooded oviparous quadrupeds, fishes and nearly all the invertebrata.

Warm blooded ~~remain in~~ retain a temperature which is nearly uniform in the 3 classes. Temp of Birds is 107° or 108°, mammalia 100 or 101, Man 97° to 98° —

Cold blooded are much less uniform, generally 1 or 2° above the medium in which they are placed.

— see pages 12. 13. 14. 15 & 16 —

Cause of Animal Heat.

1 Galen and the ancients generally, conceived animal heat to be an innate or primary quality of the body contemporary with life. Its origin supposed to be the heart, from which by means of its blood, it was distributed to all parts of the body.

2 Chemists ascribed it to fermentation of blood in the Heart and 3 the Mechanicians to friction of the particles of the blood against the sides of the vessels.

Mayows opinion. ? He concluded that the use of the lungs was not to cool the heart, but to generate heat an effect which is brought about by the absorption of the nitro-aereal spirit of the air. this mixing with the sulphureous particles of the blood, he said excited a species of fermentation by which heat was produced.

Blacks opinion. He inferred that respiration was a species of combustion, and that the heat thus ~~generated~~ extricated was employed in preserving the temperature of the animal body above that of the surrounding medium. He afterwards abandoned this theory —

Lavoisiers was the same as Blacks —

If either of these had been correct, the lungs should be the warmest parts of the body.

Crawfords theory — was the most important and rested upon 3 positions —

1st That heat is generated in lungs from the action of the air on the blood, just as in a case where oxygen and carbon combine

2nd By the same process venous blood is converted into arterial blood — but the arterial has a greater capacity for heat than venous — as 114° to 100 — therefore the extra heat is employed in saturating the extra capacity of arterial blood and thus its temperature is kept up the same standard as that of Venous Blood —

3rd Heat is not therefore actually set at liberty in the

lungs, although arterial blood contains a greater quantity of absolute heat than venous - arterial blood in passing into venous during its circulation is deprived of its extra caloric and thus the system is heated.

This removed the objection that was urged against the theory of Black -

Now during respiration the extra quantity of heat is got rid of in three ways -

1st. Part counteracts the effect of cold air taken into the lungs -

2nd Another portion produces the Vapour expired -

3rd whilst the third portion supplies the arterial blood with what is requisite.

The Blood according to Crawfords theory is not warmed in the lungs, it is in the capillaries that it gives out its caloric.

Crawfords theory then rests upon three points :-

1st. That the combustion of Oxygen & Carbon in the lungs generates heat. 2. That arterial blood has a greater capacity for heat than venous. 3 That the blood in both sides of the heart is of equal temperature. To the first of these propositions no objection can be urged, but how to dispose of the last is the question. Davy has shown that the specific heat of arterial is a degree or two greater than that of venous -

Brodie's theory - He proves that animal heat is owing to

nervous Influence - He decapitated an animal, and carried on artificial respiration, the change from venous to arterial blood took place, yet the animal temperature was not kept up - on the contrary the animal got cold - (Kirkes page 183)

Brodie's second experiments with narcotics produced the same result -

Objections - 1st - He blew too much air, greater than would have been used by the animal, and consequently cooled the animal too much.

The air in a living animal also gets warmed on passing through the air passages before it reaches the lungs, as I have explained in my lectures on Respiration - This is also against Brodie's Theory -

2nd objection - Crawford never stated that it was in the lungs that animal heat took place, but in the capillaries - hence Brodie's experiments do not invalidate the position he takes up.

Dr Wilson Philip was a defender of the theory of the nervous system causing the animal temperature - he stated that Brodie injected too much air, he injected less and found that the cooling of the body was greatly retarded -

He also thought that extrication of heat was the result of electrical action on the blood, because that the blood became warm on electricity being applied to it. He considers nervous and electrical fluids identical.

Means by which the animal Temperature is regulated -
The means by which the heat of the body is prevented from rising above its normal standard, even in the midst of a very high temp^r in the surrounding air, are of a most simple character - The excreting action of the skin is directly stimulated by the application of warmth to the surface; and the fluid which is poured forth, being immediately vapoised, converts a large quantity of sensible caloric into latent, and thus keeps down the temperature of the skin. By this provision, the body may be exposed with impunity to dry air of 600° or more; so long as the supply of fluid be maintained. But it cannot long sustain exposure to air saturated with vapour, even though it may not be many degrees hotter than the body; because the cooling effect of evaporation from the skin cannot then be carried on.

As examples of exposure to a great temperature I will mention the following: -
Tillet & Duhamel gave an account of some young women the servants of a baker at Rochefoucault, who were in the habit of going into heated ovens, in order to prepare them for the reception of the loaves.

The Temp^r. in some cases was as high as 278°, and this heat it is said they were able to endure for 12 minutes -
Fordyce, Blagden and others, performed a series of

In one of his experiments Sir Charles Blagden remained 8 minutes in a temperature of 260°—

& but provided the air be dry and free from moisture, a great heat can be for a time borne, which in fact explains the reason of the success of the experiments just related.

Delaroche and Berger observed that the temperature of rabbits was raised only a few degrees when they were exposed to heat varying from 122° to 194°. But such heats are not tolerable when the air is moist as well as hot, so as to prevent evaporation from the body. M. C. James states that in the vapour baths of Nero he was almost suffocated in a temperature of 112°, while in the caves of Testaccio, in which the air is dry, he was little discomforted by a temperature of 176°. In the former evaporation from the skin was impossible; in the latter, it was, probably, abundant, and the layer of vapour which would rise from all the surface of the body would, by its very slowly conducting power, defend it for a time from the full action of the external heat.

6.

experiments, they remained in a heated chamber, the tempr of which was considerably above that of boiling water (212°), for almost an indefinite length of time without any inconvenience. They admit that perspiration freely occurred — # (workmen of Sir F. Chantrey)

Men have worked in Pottery ovens at a Tempr of 350°.

The Fire King has submitted himself to a Temp of from 400° to 450° — & 600°.

Franklin many years ago, suggested that perspiration was of great use in regulating the animal heat.

When the surface is exposed to a high degree of external heat, the increased amount of fluid set free from the perspiratory glands becomes the means of keeping down its own temperature; for this fluid is then carried off in a state of vapour, as fast as it is set free, and in its change of form it withdraws a large quantity of caloric from the Surface. θ

Nervous Influence in animal heat, is said to be shown in cases of paralysis, when the affected limbs became colder than the sound, but this is said to be due to the Chemical Theory, as there is an alteration or deficiency in the supply of blood — We shall see if this latter opinion is correct, as we proceed.

Legallois in his experiments did not obtain the same results as Sir B. Brodie

He found that 1st artificial respiration retarded cooling by 1 to 3°

2 that when cooled to a certain period they gave out
new heat. 3. Inflation of Lungs lowers their temperature.
4. Same effects follow any circumstance that interferes
with respiration. - see pages 16. 17 & 18 -

An attempt to determine the correctness of the Chemical
Theory was made by Dulong and Despretz. Dulong in=
troduced different mammiferous animals, carnivorous as
well as herbivorous, into a receiver, in which the changes
produced in the air by respiration, and the volume of
the different products, could be determined at the same
time that the amount of heat lost by the animal
could be ascertained. His experiments led him to con-
clude, among other points, that supposing all the
oxygen, absorbed into the blood from the air in the
lungs, were combined with carbon and hydrogen in the
system, and that as much heat were thus genera-
ted as would be developed during the quick com=
bustion of equal quantities of oxygen & carbon,
and of oxygen and hydrogen, still, the whole quan=
tity of heat produced would amount to only from
3/4 to 4/5 of that which is developed during the same
space of time by carnivorous as well as herbivorous
animals. Despretz placed animals in a vessel sur=
rounded with water; an uninterrupted current of
air to and from the vessel, was maintained, and
the volume and composition of the air employed

re ascertained both before and after the experiment
hich was continued 1½ or 2 hours) as well as the in=
rease in the temperature of the surrounding water during
t: by this means it was found that the heat which
hould have been generated, according to the Chemical
teory of respiration, would account for from 0.76 to
.91 only of that which the animals really gave out
uring the same time. The failure of these experiments
t account for all the heat produced threw doubts
n the chemical theory of animal heat, till Liebig
ately showed that Dulong and Despretz were in error
 their conclusions, from having formed too low an
stimate of the heat produced in the combustion of
arbon and hydrogen. On repeating their experiments,
nd using the more accurate numbers to represent
he Combustion-heats, Liebig finds reason to believe
hat the quantity of heat which would be generated,
y the union of the oxygen absorbed into the blood
rom the atmosphere with the carbon and hydrogen
taken into the system as food, is sufficient to
ccount for the whole of the caloric formed in
he animal body.

In Hybernating animals, when in a torpid state, the
animal heat is very much diminished, the respi-
ration is however kept up, though slowly and
almost imperceptibly performed - This lowness

of the animal heat is due however to the diminished respiration. Saissy could not put animals in a torpid state, before their respiration could be decreased to a low temperature.

The precise mode in which the Carbon of the Lungs is united with the oxygen derived from the atmosphere, is not yet known. But it is certain that, in whatever manner the combination takes place, a certain measure of caloric must be generated. It appears however that from various experiments, the whole quantity of caloric generated by an animal in a given time, is greater than that which would be evolved by the combustion of the carbon, included in the carbonic acid evolved during the same time. Hence it is evident that other chemical processes occurring within the body are concerned in the maintainance of the temperature, and it is not difficult to point to some of these. It is probable in the first place, that some of the hydrogen of the food may be "burned off" by union with the oxygen of the atmosphere, so as to form part of the water exhaled ~~by~~ from the lungs. Again, the sulphur and phosphorus of the food are converted, by oxygenation, into sulphuric and phosphoric acids; in which process heat must be generated. In the composition of urea moreover, oxygen is present in much larger

proportion, than it is in the proteine-compounds by the metamorphosis of which it is formed; so that in its production too, caloric will be generated.

In fact it may be stated as a general truth, that the whole excess of the oxygen absorbed over that which is contained in the carbonic acid exhaled, must be applied to purposes in the laboratory of the system, in which caloric will be generated.

Still, the amount of carbonic acid exhaled must always be the measure of the chemical processes, by which heat is generated in the body; because it is itself the result of the chief of these processes (the union of carbon and oxygen), and because the surplus amount of oxygen which is absorbed, and which is applied to other purposes, entirely depends upon it.

It appears that there is not merely a difference in calorifying power at different ages, but at different seasons; the amount of heat generated in summer not being sufficient, in many animals, to prevent the body from being cooled down by prolonged exposure to a temperature, which is natural to them in winter. To what extent this is the case with man, it is difficult to say. His constitution is distinguished by its power of adapting itself to circumstances; and he can live

nder extremes of temperature more wide than those,
hich most other animals endure. Whether in the
orrid zone (Temp in India is sometimes 132°) or in the
rctic regions, he can maintain his healthy condition
nder favourable circumstances; in each case his
atural appetite leading him to the use of that kind
nd amount of food, which is best suited to the
ants of his system.

But the longer he has been habituated to
very warm or a very cold climate, the more
ifficult he at first finds it to live comfortably
n one of an opposite character; as his constitution
aving become adapted to one particular set of
ircumstances, requires time, to accommodate
itself to an opposite one.

For page 1 — 12

The average temperature of the human body, in those internal parts which are most easily accessible such as the mouth, and rectum, may be estimated at from 98° to 100° F. In children the temperature is commonly as high as 102° F. In old persons it is about the same as adults. Of the external parts of the body the temperature becomes lower, the further they are removed from the centre of the body; thus in the human subject, a thermometer placed in the axilla was found by Dr John Davy to stand at 98° F, at the loins it indicated a temperature of 96½°, on the thigh 94°, on the leg 93° or 91°, on the sole of the foot 90°.

In disease the temperature of the body may deviate several degrees above and below the average of health. In some diseases, as scarlatina and typhus, it rises as high as 106° or 107° F; and in children, M. Roger has observed the temperature of the skin to be raised to 108.5° Fah.

In the morbus caeruleus in which there is defective arterialization of the blood from malformation of the heart, the temperature of the body is often as low as 79° or 77½; in the Asiatic cholera, a thermomemeter placed in the mouth sometimes rises only to 77° or 79°. M. Roger observed the temperature of the body in children to

be sometimes reduced in disease to 74.°3.

The temperature of the body in health, is about 1½° F lower during sleep than while awake. According to Dr Davy it is highest in the morning after rising from sleep, continues high, but fluctuating till evening, and is lowest about midnight. Sustained mental exertion elevates it slightly; continued bodily exercise does so to a considerable extent; after feeding also it is somewhat raised. All these facts are important, both as showing variations in the temperature of the body, correspondent with those in the production of carbonic acid in the same circumstances, and as proving that the influence which slight changes in the organic economy of warm blooded animals have is as great or greater than that exercised by even extreme variation in the external temperature to which they are exposed.

For in warm climates Dr Davy found the temperature of the interior of the body only from 2.7° to 3.6° F higher than in temperate climates; and during the voyage of the Bonite, the French naturalists, who had an opportunity of observing the influence of various climates on the same persons, found that the temperature of the human body rises & falls in only a slight

degree, even in extremes of external temperatures; that it falls slowly in passing from hot to cold climates, and rises more rapidly in returning towards the torrid zone: but that these changes in the temperature of the body are more considerable in some individuals than in others.

The temperature maintained by mammalia in an active state, according to the tables of Tiedemann and Rudolphi, averages 101°. The extremes observed by them were 96° & 106°; the former in the narwhal, the latter in a bat. In birds, the average is as high as 107°; the highest temperature, 111.25° being in the small species, the linnets, &c. Among reptiles, Dr John Davy found that while the medium they were in was 75°, their average temperature was 82.5°. As a general rule, their temperature, though it falls with that of the surrounding medium, is in temperate media, 2 or more degrees higher; and though it rises also with that of the medium, yet at very high degrees ceases to do so, and remains even lower than that of the medium. Fish, Insects, and other Invertebrata present, as a general rule, the same temperature as the medium in which they live, whether that be high or low; only among fish, the

tunny-tribe, with strong hearts, and red meat like muscles and more blood than the average of fish have, are generally 7° warmer than the water around them.

The difference therefore between what are commonly called the warm- and the cold blooded animals, is not one of absolutely higher or lower temperature; for the animals, which to us, in a temperate climate, feel cold (being, like the air or water, colder than the surfaces of our bodies), would, in an external temperature of 100° or 200°, have the nearly same temperature, and feel hot to us. Humboldt and Bompland saw fish thrown up from volcanoes alive, and apparently in health, along with water and vapour which raised the thermometer to 210°.

The real difference is, as Mr Hunter expressed it, that what we call warm blooded animals (birds and mammalia), have a certain "permanent heat ✗ in all atmospheres," while the temperature of the others, which we call cold-blooded, is "variable with every atmosphere".

The power of maintaining an uniform temperature, which Mammalia and birds possess, is combined with the want of power to endure

such

changes of temperature as are harmless to the other classes; and when their power of resisting change of temperature ceases, they suffer serious disturbances ~~and~~ or die. M. Magendie has shewn that birds and rabbits die when, being exposed to great external heat, their temperature is raised as much as 9° above the natural standard; and it is probable that a reduction of the temperature of the interior of the body to the same amount would be very dangerous, if not fatal.

— For Page 7 —

The experiments which best illustrate the influence of the nervous system in modifying the production of heat, are those shewing first, that when the supply of nervous influence to a part is cut off the temperature of that part falls below its ordinary degree; secondly, that when death is caused by severe injury to, or removal of, the nervous centres, the temperature of the body rapidly falls, even though artificial respiration be performed, the circulation maintained, and to all appearance the ordinary chemical changes of the body be completely effected. It has been repeatedly noticed that, after division of the nerves of a limb, its temperature falls: and this diminution of

hat has been remarked still more plainly in limbs deprived of nervous influence by paralysis. For example Mr Earle found the temperature of the hand of a paralysed arm to be 70°, while that of the sound side had a temperature of 92° F. On electrifying the paralysed limb, the temperature rose to 77°.

In another case, the temperature of the paralysed finger was 56° F, while that of the unaffected hand was 62°. Of this fact, the lessened temperature of the paralysed limbs, I have frequently satisfied myself when residing in an Hospital and you can prove the correctness of the experiment at any time.

Sir Benj^n Brodies experiment I have already related; it was undertaken to prove that Animal Heat was due to nervous Influence, but the result proved quite the reverse, as the animal got more rapidly cold by the forced air in the lungs, than the body of one in which artificial respiration was not kept up. With equal certainty, though less definitely, the influence of the nervous system on the production of heat is shewn in the rapid and momentary increase of temperature, sometimes general, at other times quite local, which is observed in states of nervous excitement; in the general increase of warmth of the body, sometimes amounting to perspiration, which is excited by passions of the mind; in the sudden rush of

heat to the face, which is not a mere sensation; and in the equally rapid diminution of temperature in the depressing passions.

But none of these instances suffice to prove that heat is generated by mere nervous action, independent of any chemical change; all are as well explicable on the supposition that the influence of the nervous system alters, in some way, the chemical processes from which the heat is commonly generated.

There are ample proofs that the nervous system, especially in the most highly organised animals, does so modify all the functions of organic life; and it appears more reasonable to suppose that it thus influences the production of heat, than to ascribe it to any mere direct agency. (Kirkes p. 183)

21

Motion - Pus and Milk

J. D. Gibb M.D.

14 July. 1857

To illustrate

drawing, Amer Kirkes. p 366. Cilia
do page 62 of Todd
do of Infusoria, from Prichard.

Write this Lecture over, and modify and add to it from Todd and Kirkes. Have a separate and distinct Lecture on Pus and Milk and consult Hassall, particularly for the latter.

The 2 together give a good lecture with the aid of the Microscope.

Motion. The minute movements occurring in the [in]terior of the body, may be divided into 3 Kinds:—

1. Those in which particles are moved or propelled by a [po]wer independant of themselves.

2. Those accompanying the incessant changes of the [or]ganic elements of the tissues.

3. Those which occur in certain entire tissues on [the] application of an appropriate stimulus.

All these movements may be called Molecular [on] account of the minuteness of the particles concerned [in] them.

1. Molecular motion - Mr Robert Brown - He thought [tha]t organic vegetable and animal substances, when [f]initely divided and suspended in water were capa[b]le of motion of an oscillatory and rotatory kind - [bu]t their movements depend altogether upon currents [in] the water produced by evaporation going on, on [its] surface and at its edges - This can be readily [pr]oved by adding a small quantity of oil to the [w]ater which at once, by evaporation arresting, [s]uspends the movements of the bodies.

2. Organic Molecular Motion. Some of the motions going [o]n in the body, are mainly identical with that [d]escribed by Mr Brown. Such forces are not gen[e]rally speaking visible, but their existence can be inferred - of this kind are the motions within cells,

To illustrate Milk & Pus.

drawings of pus
do — of milk
see also Lancet for 1851 – drawings of milk.
Milk ducts. Ferm Camp p 624
Claquets plates, mammary gland.
see Hassells work, milk &c
Mammary gland. plate 54. Hassall

Microscope fresh pus & milk, colostrum &c
at Lying in Hosp if possible.

hich are either purely rythmical, or irregular and osc=
illating - The former kind of motion exists in the
yclosis and Chara (Vegetables); the granules are
uite passive, and are carried along by currents
ithin the cells of the Plants.

Schwann has likewise described motions of the
same kind as occurring with granules within the
ells of the germinal membrane in a hens egg,
which appeared to be produced by endosmotic
urrents through the walls of the cells - In this
nstance the contained particles are quite passive,
nd their movements depend altogether upon
urrents -

A movement of the same kind goes on in
e Choroid coat of the Eye, but it is not yet
ct ascertained if it goes on during life -
Movements of this kind are seen in the blood -

Organic Molecular Motion, occurs in almost
ll the processes within the body. By this kind of
motion, the nutritious, is separated from the in=
utritious portions of food; by it, the nutritious
articles are taken and carried into the system,
nd the effete particles are removed from the sys=
em. By it probably the separation of the organic
from the inorganic compounds takes place in glands.
These motions of the inorganic and organic elements
are incessant.

3 The Molecular movements existing between nerves and
nd muscles under stimulation cease with life.
In Muscular movement there is a perceptible ap-
proximation of the ultimate particles of the tissue
in a determinate direction. This was explained in
my lectures on Muscle -

Ciliary Motion - This singular phenomenon we
will place in the same category with the molecular
motion.
Many lubricated surfaces are covered with a multitude
of hair-like processes, of extreme delicacy of structure
and minuteness of size. These are called cilia,
from cilium, an eye lash.
Their shape is Conical, sometimes flattened, attached
by bases to the epithelium that covers the surface on
which they play, and tapering gradually to a point. see fig.
They vary in length from the 500 to the 13.000 of an
inch. They are arranged in Rows. During life and
even after death, they possess a peculiar Fanning
motion. The motion of cilia to sopes resemble the
waving of a field of corn under a high mic: power.
In the gills of the River Muscle, the movements of the
ciliae exist for days after the death of the
animal - (show all the Figures)

The purpose of the ciliary movement is to propel fluids

‡ (ciliary motion) has been ascertained to exist on several surfaces:—

& So delicate are the cells of epithelium here, that the slightest mechanical injury destroys them; it is therefore very difficult to see this movement. Valentin states that its duration is considerable in these parts, so that it may be seen in subjects used for dissection.

⊙. on the membrane lining the

×. the os uteri, through its cavity, and through the Fallopian tubes to their fimbriated margins.

In Mammalia there is no instance of ciliae occupying any part of the urinary mucous surface; but in reptiles it lines the urinary tubules to a greater or less extent, and sometimes, though not generally, proceeds within the Malpighian capsules. This has been frequently seen in the Frog, and is shewn in the accompanying drawing.— (Fig 3 Todd)

The movement is here directed towards the uriniferous tube, and it doubtless is destined to favour the flow of the aqueous portion of the secretion from the capsule to the tube. (Todd)

over the surface on which it takes place. In man it exists 1 on the surface of the ventricles of the brain and on the choroid plexuses. & 2 on the muc: mem: of the nasal cavities, extending along the roof of the pharynx to its posterior wall, on a level with the atlas, on the upper and posterior part of the soft palate, and in the immediate vicinity of the Eustachian tube, extending through the latter itself to the cavity of the tympanum.
3° In the frontal, sphenoidal & superior maxy sinuses. On the inner surface of the lachrymal sac & canal. On the mem: of the larynx, trachea, & bronchial tubes. On the lin: mem: of the female organs of generation, except the vagina. But it may be traced from the lips of *.

Speak of the Infusorial animalcules and point out the drawings of —
Ciliae exist in some of their bodies, as well as on the surfaces. If not they could not procure their food nor move along, they have no powers of prehension. When in an active state they pass so rapidly through the fluid, that you can scarcely examine them, but when they die they can be observed. The Ciliae serve to produce currents and draw their food towards them. Many have 20 or 30 stomachs.

It is curious that in man mucus secreted in the lungs cannot be detected till it gets near the throat; advancing against the laws of gravity; this has been attributed

the ciliae which moving to & fro convey the mucus
outwards. Cilia in the uterus go towards the
vagina. Ciliary motion is not induced by elec=
tricity, and it is entirely independant of nervous
influence. Ehrenberg passed all his life in study=
ing Infusoria. see pages 8 & 9 -

Pus and Milk, Microscopical characters.

These are very important. pus may exist in the urine
which is not perceptible to the naked eye -
what class of cases - &c
In hysteria patients often desire to practice imposition
and mix milk with their urine, there is no such
disease as milky urine, there is a chylous urine -
(Pet Rout).
Pus globules are found in the urine in the gouty
diathesis. Urine does not remove pus from
organs or cause the disappearance of abscesses.
Pus is divided into the Liquor Puris and Pus
globules. Liquor Puris is water containing albumen.
all urine containing pus is albuminous.
(show drawings) Under the microscope pus is found to
consist of opake, spherical globules (as I will pre=
sently show) apparently granulated like Mulberries
but in reality smooth. Size 1.5000 to 1.2000 of
an inch in diameter, some are even much larger.
They may be shown to consist of a an envelope,
or cell membrane, containing nuclei, oil globules,
and minute granules.. If acetic acid be added

6

t brings clearly into view, 2, 3, or 4 nuclei, and renders
the other parts transparent, or so invisible that
they seem to have dissolved. They are not really
dissolved, because the nuclei retain their adhesion
to each other; and liquor potassae partially restores
the original appearance.

Show pus under microscope.

Origin of pus globules See Vogel & Müller
p. 144 & 145.

Various Kinds of pus. see Br. Am. Jour.
and colours assumed by pus.

Milk. In milk, the albuminous group of aliments
is represented by the caseine, the oleaginous by the
butter, the aqueous by the water, and the
saccharine by the sugar of milk. Milk likewise
contains likewise contains phosphate of lime, alka
line and other salts and a trace of iron.
So that it may be said briefly to contain all the
substances which the tissues of the young need
for nourishment, and which are required for
the production of animal heat.

Microscope. appearances. Show the microscope —
describe the globules, round, smooth, varying in
size; floating freely & not adhering —

From bottom of 7

Milk in Breasts of children - possessing ordinary char of milk, with even colostrum - McE's case

Different Kinds of Milk - difference very slight in animals - globules of goat small -

Good Healthy woman milk - alkaline - 1032 numerous globules -

If the milk is viscous or acid, the globules ill formed or few in number, if adhere together in masses & do not roll freely in the serum & if also colostrum, then the milk is bad or diseased -

Of Poor Milk & Rich Milk

Adulterations of Milk - Starch - Sheeps Brains - &c - Show drawings -

Occurrence of Medicines in Milk -

For page 5

If a portion of <u>ciliary mucous membrane</u> from a living or recently dead animal be moistened, and examined with a microscope, the cilia are observed to be in constant motion, either whirling round their fixed extremities so that their ends describe circles, or waving continually backwards and forwards, and alternately rising and falling with a lashing or fanning movement. During the lashing movements each of the cilia performs a motion somewhat similar to that performed during the feathering of an oar in rowing: hence the general result of their movement is to produce a continuous current in a determinate direction; and this direction is invariably the same on the same surface, being usually towards its external orifice. In the production of such current consists the principal use of the cilia, which are thus enabled to propel the fluids or minute particles which come within the range of their influence, and to aid in their expulsion from the body. In the Fallopian tube the direction of the current excited by the cilia is towards the cavity of the uterus, and may be thus of service in aiding the passage of the ovum. Of the purposes served by cilia covering the surface of the cerebral ventricles nothing is known.

The nature of the ciliary motion, and the cause on which it depends, are equally obscure. It seems to be alike independant of the will, of the direct influence of the nervous system, and of muscular contraction; for it is involuntary; there is no nervous or muscular tissue in the immediate neighbourhood of the cilia, and it continues for several hours after death or removal from the body, provided the portion of examined tissue is kept moist. Its independence of the nervous system is shown also in its occurrence in the lowest invertebrated animals apparently unprovided with anything analogous to a nervous system, in its persistence in animals killed by prussic acid, narcotic or other poisons, and after the direct application of narcotics to the ciliary surface, or the discharge of a Leyden jar, or of a galvanic shock through it. In their rythmic action and its persistence after death or removal from the body, the ciliary movements bear a close analogy to those of the heart: and the analogy is made closer by both kinds of movements being diminished by cold and increased by heat.

If room ℞ page 66 of Todd
& show plate 16 of Hassall –

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Good and Bad Milk. difference between the 2. see below ⊗

First nurses are not so good as those who have had 2 or 3 children.

Specific gravity of Cows milk is from 1023 to 1031. Or the average of morning milk 1029 & evening do 1027.

Colastrum Milk secreted first few days after child birth has been called the Colastrum - differs much from ordinary milk, being of yellow colour, viscid & containing large proportion of milk globules - (show plates)

⊗ Persistence of this Fluid in Condition of Colastrum. Should disappear at 24th day. this exerts most injurious effect on the child - it possesses purgt properties, very necessary first days of life - Speak of nurses bad milk -

Recurrence of the colastrum -

Influence of prolonged retention of milk on the constitution - becomes thin & watery - Effects of -

Pus & Blood in milk -

Milk of Syphilitic women - nothing detected -

The milk of unmarried women. Contains colastrum &c

Milk of women previous to confinement - large quantity & contains colastrum -

see opposite page

22

Digestion. No. 1

George D Gibb MD

5 August 1857

To illustrate

Infusoria, to show stomachs of many of them.
as simple pouch - Coecal stomachs
Polygastrica - mouth and anus &c.
Stomachs of animals.
Intestinal tube of fish
Crop of fowls
Classification of Mammalia
Stomach of a sheep, a horse & a pig.
Caecum of a horse
Sol per Mt Fer to show sulpho-cyanogen.

add a page of experiment from Kirkes at page 10 of Lect.

Digestion is the process by which those parts of our food which may be employed in the formation and repair of the tissues, or in the production of heat, are made fit to be absorbed and added to the blood.

In man and the higher animals several organs are necessary to the performance of this function, whilst in the lower animals only the essentials exist and the accessories increase as we ascend in the scale. There is a most intimate relation between the food and the digestive apparatus.

The simplest form of digestive apparatus is a pouch with one orifice for the mouth and anus as in the Infusoria and the effete matter is got rid of by an effort like that of vomiting. (see Figures

In some where there is only the single cavity many caecal stomachs open into it and are attached like a compound gland. Next in the polygastrica there is an orifice for the mouth and another for the anus, all the stomachs communicate with a middle tube, which terminates in the anus. We next meet with a mouth and oesophagus and perhaps a pharyngeal tube; next, in addition an intestinal tube, upon which the stomach is a mere dilatation, — as in the Vertebrata.

In Fishes the intestinal tube is very short & simple,

except in the Shark and Dog Fish which have a spiral valve like membrane in the small intestine, this in=creases the surface and extends half way into the calibre of the gut. (see Fig [illegible]

2 In birds the graminivorous have a complex apparatus. 1st a crop where the grain is macerated and softened and also a series of glands to increase the secretion, then enters the gizzard or stomach, which has a hard, horny lining membrane (which however is thin in Carnivorous Birds) and has 4 setts muscles acting in different ways, producing a grinding motion and thus reduces the food into chyle.

1 In Reptiles the stomach is very variable in shape and capacity; it is for the most part pyriform, and is capable of great dilatation. The stomach of the Crocodile very much resembles the gizzard of a rapacious bird, and in this shows the gradual transition from one class of animals to that which next succeeds it in the series of Creation.

In the Mammalia, nearly all the class are provided with teeth destined to divide their food, but the number and form of these organs varies according to the habits of the animal. In whales the teeth are replaced by horny plates, termed whalebone. In the ornythorincus or duck billed platypus, the muzzle is prolonged into a beak resembling that of a duck, and possessing no teeth.

The Mammalia are divided into the Vegetable and flesh-eating animals - (Refer to Classification)

In the Graminivora the intestinal tube is very complex in its formation, whilst in the Carnivora it is simple owing to the near approximation of animal food to the body of the animal. In Lynx there is only a straight tube with a new dilatation as in fish. (In bird there is the [illegible] Electric Eel, simple stomach and long tube with few complication. If we compare this with the Reindeer we find that it possesses a complicated intestinal apparatus, and more so in the Cow and sheep.

In the Rodentia such as the hamster and water rats, the stomach is already divided into 2 parts. In the great Kangaroo it has 3 compartments. In the Sloth even 4. Among some of the apes, a compound stomach, consisting of 3 portions.

In the Solidungula (the horse, ass &c) the stomach is simple, its regions being distinguished merely by the extension of the epithelium from the oesophagus over the cardiac portion. In the Pachydermata is generally simple. In the Ruminantia (sheep, cow &c) there are 4 stomachs; and it is the last of these which has the acid property common to the organ in other mammalia. The first three cavities have a distinct lining of epithelium, and may be regarded as divisions of the cardiac portion of the stomach, for the softening of the vegetable food preparatory to digestion true. The first compartment is the paunch, it possesses

flattened papillae on its inner surface; it effects little change in the food which is in it, subjected to maceration by the saliva. The second, small stomach, the reticulum, communicates freely with the paunch, & is distinguished by the honeycomb-like denticulated folds of its lining membrane. In the third stomach, the manyplies or omasum, the mucous membrane is thrown into numerous longitudinal folds, arranged side by side like the leaves of a book. The food having been softened in the 1st & 2nd stomach, is after a certain time returned to the oesophagus and mouth and having been a second time masticated descends thro the oesophagus into the third stomach, and thence passes by a narrow opening into the fourth the abomasum, of which the mucous mem: is soft and the form elongated almost like that of the intestine. The first and second stomachs may be regarded as diverticula from the cardiac portions of the oesophagus and stomach. The opening by which they communicate with the oesophagus can be closed so that the morsel of food is made to pass onwards directly into the 3d stomach without entering the first & second cavities —

In the Cetacea the stomach of both the vegetable and animal feeders is complex in structure —

Carnivora alimentary canal is shorter than in any others, there is scarcely any distinction between the small and large intestines. Whilst in most Herbivora:

the colon is very wide and very long –

The caecum also differs according to the food of the animal – generally small in the carnivora, whilst in the Solidungula, Ruminantia and most Rodentia, it is very long, – for example, in the horse it measures 2½ feet, in the beaver 2 feet.
(Faeces of hare & goat are in pellets according to the cells of the gut)

In the Camel there are 4 cavities in the stomach. This animal "the Ship of the Desert" lives 9 days without drinking a fresh supply, and in each cavity circular bands of muscular fibre exist, which keep the water pure.

The Acts connected with the process of Digestion are Prehension, Mastication, Insalivation, Deglutition, Chymification, Chylification & defaecation. All of these will come under consideration in the course of these lectures on Digestion. But we shall first consider the Food of Man.

Food may be considered in its relation to ~~the~~ two purposes, 1st In the formation and repair of the tissues 2nd in the production of heat. And the various articles of food may be artificially classified according as they are chiefly subservient to one or the other of these purposes. All articles of food that are to be employed in the production of heat, must contain a larger

proportion of carbon and hydrogen than is sufficient to form water with the oxygen they contain, and none are proper for the maintainance of any tissues (except the adipose) unless they contain nitrogen, and are capable of conversion into the nitrogenous principles of the blood.

The name of nutritive or plastic is given to those principles of food which admit of conversion into the albumen or fibrine of the blood, and of being subsequently assimilated, through the medium of the blood, by the tissues. And those principles, comprising the greater part of the non-nitrogenous materials of food, in the form of fat, starch, gum, sugar and other similar substances, which are believed to be employed in the production of heat, are named calorifacient, or sometimes respiratory food.

Animal and vegetable food - Man is supported as well by food constituted wholly of animal substances as by that which is formed entirely of vegetable matter; and the structure of his teeth, as well as experience, seems to point out that he is destined for a mixed kind of aliment. In the case of Carnivorous animals, the food upon which they exist, consisting as it does of the flesh and blood of other animals, not only contains all the elements of which their own blood and tissues are composed, but contains them combined, probably, in the same forms. Therefore little more may seem requisite, in the preparation of this kind of food for the nutrition of the body, than

that it should be dissolved and conveyed into the blood in a condition capable of being re-organized. But in the case of the herbivorous animals, which feed exclusively upon vegetable substances, it might seem as if there would be greater difficulty in procuring food capable of assimilation into their blood and tissues. But the chief ordinary articles of vegetable food contain substances identical in composition, with the albumen, fibrine and caseine which constitute the principal nutritive materials in animal food. Albumen is abundant in the juices and seeds of nearly all vegetables; the gluten in corn and in the seeds and juices of other grasses, is identical in composition with fibrine & is now called vegetable fibrine; and Legumin, obtained from peas, beans and other leguminous plants & from the potato, is identical with the caseine of the milk. All these vegetable substances are, equally with the corresponding animal principles, and in the same manner, capable of conversion into blood and tissues; and like the blood and tissues in both classes of animals, the nitrogenous food of both may be regarded as similar in all essential respects.

Food both animal and vegetable, may be arranged according to Dr Prout's system in 3 classes - the albuminous, saccharine and oleaginous - The albuminous comprises all the nitrogenous principles whether derived from the animal or the vegetable kingdom;

These are albumen; fibrine, caseine, gelatine & chondrine.
The Saccharine group comprises substances derived exclusively from the vegetable kingdom, viz sugar itself, and principles capable of conversion into it, as starch, gum; pectine and lignine, or woody fibre; all of which are composed of C. H and O, with the 2 latter in the proportion in which they form water.
The Oleaginous includes the various kinds of fatty and oily principles, which occur in both kingdoms. All are composed of principally C and H, the quantity of the former usually exceeding that of the latter, and both being more than sufficient to form water with the oxygen they contain —
Dr Prout makes a fourth div: the Aqueous part of food. Water forms 4/5 of total weight of animal body, and enters largely into compn of food —

Health cannot be maintained, by substances derived exclusively from 1 of the 3 groups of aly principles. A mixture of nitrogenous and non-nitrogenous substances is essential to the well-being and existence of the animal. The truth of this is proved by experiments and by the composition of food of young of Mammalia, viz Milk —
In Milk, the albuminous group of aliments is represented by the caseine, the oleaginous by the butter, the aqueous by the water, the saccharine by the sugar of milk. (In the Carnivora, sugar is absent in the milk). Milk, likewise, contains phosphate of lime, albumine and other salts, and a

trace of iron: so that it includes all the substances which the tissues of the Graminy animal need for their nutrition, and which are required for the production of animal heat.

Experiments of Magendie. Dogs were fed exclusively on sugar & distilled water. During first 7 or 8 days they were brisk and active, & eat and drank as usual; in the course of 2nd week they began to get thin, although their appetite was good & they took daily 6 & 8 oz of sugar. The emaciation increased during third week, they became feeble & lost their activity & appetite. At the same time an ulcer formed on each cornea, followed by an escape of the humours of the eye; this took place in repeated experiments. The animals still eat 3 or 4 oz sugar daily; but at length became so feeble as to be incapable of motion & died on the 31st to the 34th day. On dissection their bodies presented the appearance of death from starvation: indeed dogs will live almost the same length of time without any food at all —

When dogs were fed exclusively on gum, results almost similar to those related ensued. When they were kept on olive oil and water, the phenomena were the same, but with no ulceration of the cornea; the effects were the same with butter. Tiedeman and Gmelin obtained very similar results. They fed different geese one with sugar and water, another with gum and water, and a third with starch & water.

All gradually lost weight. The one fed with gum died on the 16th day; that fed with sugar on 22nd; the third which was fed on starch on 24th, and another on 27th day; having lost, from 1/6 to 1/2 their weight –

Further experiments see Kirkes & Paget –

These facts prove the necessity of a mixture of elementary principles in the food; and beyond this, Magendies further experiments appear to prove that animals cannot live long if fed exclusively on any single article of food (except milk) even although it contains principles belonging to each of the three groups of alimentary substances – e.g. dog fed on white bread, wheat, & water, did not live more than 50 days; rabbits & guinea pigs fed on any one substance, as wheat oats, barley cabbage or carrots died with all signs of inanition in 15 days –

Ibid. –

Changes of the Food effected in the Mouth –

The first of the series of changes to which the food is subjected in the digestive canal takes place in the cavity of the mouth – The solid foods are here submitted to the action of the teeth in the process of Mastication, whereby they are divided and crushed and by being mixed at the same time with the fluids of the mouth are reduced to a soft pulp capable of being easily swallowed. The fluids with which the food is mixed in the mouth consist of the secretion of the salivary glands, and the mucus

Parotid Gland   See Boerhave pl 4
fig 5. 6. 7 & 8 -

secreted by the lining membrane of the whole buccal cavity. The glands concerned in the production of Saliva are very extensive, and in man and Mammalia generally are presented in the form of 4 pairs of large glands, the parotid, submaxillary, sublingual and intralingual, and numerous smaller bodies, of similar structure and with separate ducts, which are scattered thickly beneath the mucous membrane of the lips, cheeks, soft palate and root of the tongue. These all have the structure common to what are termed conglomerate glands. Saliva as it commonly flows from the mouth, is mixed with the secretion of the mucous membrane and often with air-bubbles, which being retained by its viscidity make it frothy.

When obtained from the parotid-ducts and free from mucus, saliva is a transparent watery fluid, the sp. gr varies from 1006 to 1009 and in which when examined with the microscope are found floating a number of minute particles derived from the secreting ducts and vesicles of the glands. In the impure or mixed saliva are found beside these particles, numerous epithelial scales separated from the surface of the mucous membrane of the mouth and tongue and mucus-corpuscles, discharged for the most part from the tonsils, which when the saliva is collected in a deep vessel, and left at rest, subside in the form of a white opaque matter, leaving the supernatant salivary fluid

transparent and colourless, or with a pale bluish-gray tint.

In reaction the saliva, when first secreted, appears to be always alkaline; and that from the parotid gland is said to be more strongly alkaline than that from the other salivary glands. This alkaline condition is most evident when digestion is going on and according to Dr Wright the degree of alkalinity of the saliva bears a direct proportion to the acidity of the gastric fluid secreted at the same time.

During fasting the saliva, although secreted alkaline, shortly becomes acid; and it does so especially when secreted slowly, and allowed to mix with the acid mucus of the mouth, by which its alkaline reaction is destroyed –

According to Dr Wright the composition of Saliva is –

Water	988.1	Mucus	2.6
Ptyaline	1.8	Ashes	4.1
Fatty matter	.5	Loss	1.2
Albumen (with soda)	1.7		1000.0

Ptyaline is the name given to a supposed peculiar animal matter, which is insoluble in alcohol. By Mialhe it is stated to be closely analogous to the vegetable substance, termed diastase; but it is more commonly regarded as belonging to the ill defined class of extractive matters.

The ashes of saliva have been analyzed by Enderlin who found that they consist of substances very simi=

-ilar to those in the ashes of blood, and believes that the alkalinity of the saliva, like that of the blood, is due to the tribasic phosphate of soda. The other salts which he found in it were chlorides of sodium and potassium, sulphate of soda, and phosphates of lime magnesia and iron. Saliva is also said to contain a small quantity of sulpho cyanogen: the presence of which is indicated by a deep-red colour when saliva is mixed with a neutral solution of a salt of the peroxide of iron. (Show it) —

The tartar which collects on the human teeth consists almost entirely of the earthy phosphates, combined with about 19 per cent of animal matter, and containing shells of infusoria and other accidental mixtures.

The rate at which saliva is secreted is subject to considerable variation. When the tongue and muscles concerned in mastication are at rest, and the nerves of the mouth are subject to no unusual stimulus, the quantity secreted is not more than sufficient with the mucus to keep the mouth moist. But the flow is much accelerated when the movements of mastication take place, and especially when they are combined with the presence of food in the mouth. It may be excited also by mental impressions at the sight of food. Under these varying circumstances, the quantity of saliva secreted in 24 hours varies also;

its usage amount ranges from 15 to 20 ounces - In a man who had a fistulous opening of the parotid duct, Mitscherlich found that the quantity of saliva discharged from it during 24 hours was from 1 to 2 ounces; and the saliva collected from the mouth during the same period, and derived from the other salivary glands, amounted to 6 times more than that from the one parotid.

The Purposes served by Saliva are of several kinds. First - It keeps the mouth in a state of moisture facilitating the movements of the tongue in speaking and the mastication of food - Second It dissolves sapid substances and excites the nerves of taste - Third - and principally, by mixing with the food during mastication, it makes a soft pulpy mass such as may be easily swallowed. To this latter purpose the saliva is adapted both by quantity and quality. For speaking generally the quantity secreted during feeding is in direct proportion to the dryness and hardness of the food; as M. Lassaigne has shown, by a table of the quantity produced in the mastication of a hundred parts of each of several kinds of food; 30 parts suffice for 100 of crumb of bread; but not less than 120 for the crusts; 42.5 parts of saliva are produced for the 100 of roast meat; 3.7 for as much of apples; and so on, according to the general rule just stated.

The quality of the saliva is equally adapted to this end. It mixes more readily with most kinds of food than water alone does - as proved by the experiments of my friend M. Bernard -

Beyond its mechanical purposes, it is supposed that saliva performs some chemical part in the digestion of food. The chief reasons for this are, the number and size of the glands engaged in the secretion, the variety of substances which enter into its composition, and which can scarcely be supposed to be of use so far as its mechanical properties are concerned; the quantity which is secreted, not only during mastication but after the food has passed into the stomach, especially in old persons who from loss of teeth, frequently swallow their food imperfectly masticated; the fact that the saliva secreted during digestion is more alkaline than at other times; and lastly the result of certain experiments.

Among these latter are those of Spallanzani and Reaumur, who found that food enclosed in perforated tubes and introduced into the stomach of an animal, was more quickly digested when it had been previously impregnated with saliva than when moistened with water. Dr Wright also found that if the oesophagus of a dog is tied, & food mixed with water alone is placed in stomach, the food remains undigested; but if it is mixed with saliva, the food is readily digested -

the organic principles of saliva may have more power than the alkali in assisting digestion; for numerous experiments easily repeated, show that when saliva or a portion of a salivary gland is added to starch-paste, the starch is quickly transformed into dextrine, and grape sugar; and when common raw-starch is masticated and mingled with saliva, and kept with it at a tempr of 90° or 100°, the starch-grains are cracked or eroded, and their contents are transformed in the same manner as the starch-paste. It may therefore be held that a purpose served by the saliva in the digestive process is that of assisting in the transformation of the starch, which is converted into the soluble dextrine or grape sugar and made fit for absorption -

From the experiments of Magendie and my friend Bernard it appears that many substances besides saliva may excite the transformation of starch, such as pieces of the muc: mem: of the mouth, bladder, rectum and other parts, various animal and vegetable tissues, and even morbid products; but the gastric fluid will not produce the same effect.

The property therefore cannot be assigned to any peculiar organic principle in the saliva. The part of the saliva which appears most active is that secreted by the small glands and the mucous membrane of the mouth (Bernard).

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Digestion No. 2.

G. D. Gibb M.D.

7th August 1857

To illustrate

Drawing p 201 - Kirkes and Carpenter
do p 202 do Eng.
others from Todd & Bowman
Hassalls plates
Dr Beaumonts work.

Digestion No. 2 -

Passage of the Food into the Stomach -

When properly masticated, the food is transmitted in successive portions ~~by~~ to the stomach by the act of deglutition or swallowing. This act for the purpose of description, may be divided into 3 parts. In the first particles of food collected to a morsel glide between the surface of the tongue and the palatine arch, till they have passed the anterior arch of the fauces; in the second, the morsel is carried through the pharynx; and in the third, it reaches the stomach through the oesophagus. These 3 acts follow each other rapidly. The first is performed voluntarily by the muscles of the tongue and cheeks. The second also is effected with the aid of muscles which are in part endued with voluntary motion, such as the muscles of the soft palate and pharynx; but it is nevertheless an involuntary act, and takes place without our being able to prevent it, as soon as a morsel of food, drink or saliva is carried backwards to a certain point of the tongues surface. When we appear to swallow voluntarily, we only convey, through the first act of deglutition, a portion of food or saliva beyond the anterior arch of the palate; thus, the substance acts as a stimulus which ~~contracts~~ in accordance with the laws of

reflex movements hereafter to be described, is carried by the sensitive nerves ** to the medulla oblongata, where it is reflected to the motor nerves, and an involuntary action of the muscles of the palate and pharynx ensues. The third act of deglutition takes place in the oesophagus, the muscular fibres of which are entirely beyond the influence of the will.

The second act of deglutition is the most complicated, because the food must pass by the posterior orifice of the nose and the rima glottidis of the larynx without touching them. When it has been brought, by the first act, behind the anterior arches of the palate, it is moved onwards by the tongue being carried backwards, and by the muscles of the anterior arches contracting behind it. The root of the tongue being retracted and the larynx being raised with the pharynx and carried forwards under the tongue, the epiglottis is pressed over the rima glottidis and the morsel glides past it; the closure of the glottis being additionally secured by the simultaneous contraction of its own muscles, so that even when the epiglottis is destroyed there is little danger of food or drink passing into the larynx, so long as its muscles can act freely. At the same time the approximation of the sides of the posterior palatine arch which move quickly inwards like side-curtains close the passage into the upper part of the pharynx and the posterior nares and forms an inclined plane along the under surface of which the morsel descends; when the pharynx, raised up to receive it,

in its turn contracts, and forces it onwards into the oesophagus.

In the third act, in which the food passes thro the oesophagus, every part of that tube, as it receives the morsel, and is dilated by it, is stimulated to contract; hence an undulatory contraction of the oesophagus; which is easily observable in horses while drinking, proceeds rapidly along the tube. It is only when the morsels swallowed are large, or taken too quickly in succession, that the progressive contraction of the oesophagus is slow, and attended with pain.

Besides the actions ensuing in the oesophagus during the passage of food, certain rythmic contractions have been observed at its lower part independantly of deglutition. They are produced by the fibres near the cardiac orifice of the stomach, which fibres are usually in a state of contraction, especially when the stomach is full, and appear to act as a kind of sphincter to prevent the regurgitation of food. During vomiting they are relaxed; and at the same time the whole muscular tissue of the tube is said to perform an anti-peristaltic motion, the reverse of that which it executes during deglutition. When vomiting has been produced by the injection of tartar emetic into the veins, these anti-peristaltic motions of the oesophagus are said to be continued, even though the tube is separated from the stomach.

Digestion of Food in the Stomach

Structure of the Stomach. As I mentioned before, all animals possess a cavity for digesting their food, and the most important changes occur in that part of it, termed the stomach.

In man and those Mammalia which are provided with a single stomach, its walls consist of 3 distinct layers or coats, viz, an external peritoneal, an internal mucous, and an intermediate muscular coat, with bloodvessels, lymphatics and nerves distributed in and between them. In relation to the physiology of the stomach in digestion, only the muscular and mucous coats need be considered.

The muscular coat of the stomach consists of 3 separate layers, or sets of fibres which according to their several directions are named the longitudinal, circular or oblique. The longitudinal set are the most superficial: they are continuous with the longitudinal fibres of the oesophagus and spread out in a diverging manner over the great end and sides of the stomach. They extend as far as the pylorus being especially distinct at the lesser or upper curvature of the stomach, along which they pass in several strong bands. The next set are the circular or transverse fibres, which more or less completely encircle all parts of the stomach; they are most abundant at the middle and in the pyloric portion of the organ, and some form the chief part of the thick projecting ring of the pylorus. The next and consequently deepest set of fibres are the

oblique; they are comparatively few in number, and are placed only at the cardiac orifice and portion of the stomach, over both surfaces of which they are spread, some passing obliquely from left to right, others from right to left, around the cardiac orifice to which by their interlacing they form a kind of sphincter, continuous with that round the lower end of the aesophagus.

The mucous membrane of the stomach rests upon a layer of loose cellular membrane, or submucous tissue, which connects it with the muscular coat, and contains its principal bloodvessels. Examined when the stomach is distended, it is smooth, level, soft, and velvety; in the contracted state it is thrown into numerous, chiefly longitudinal folds, or rugae. When examined with a lens, the internal or free surface, as was first accurately pointed out by Dr Spratt Boyd, presents a peculiar honey comb appearance produced by shallow polygonal depressions or cells (figure 12 p 201 [illegible]) the diameter of which varies generally from $\frac{1}{200}$ to $\frac{1}{350}$ of an inch; but near the pylorus is as much as $\frac{1}{100}$ of an inch. They are separated by slightly elevated ridges, which sometimes, especially in certain morbid states of the ~~[illegible]~~ stomach, bear minute, narrow, vascular processes that look like villi, and have given rise to the erroneous supposition that the stomach has absorbing villi like those of the small intestines. In the bottom of the cells minute openings are visible (Fig.) which are the orifices of perpendicular glands

imbedded, side by side in sets or bundles, in the substance of the mucous membrane, and composing nearly the whole structure. (Fig 154. 155. 156 2nd ed)

These tubular glands vary in length from one fourth of a line to nearly a line; they are longer and more thickly set towards the pylorus than elsewhere, their length is equal to the various thickness of the mucous membrane of the stomach at different parts. At their bases, which rest on the submucous tissue, they measure about $\frac{1}{300}$ of an inch in diameter, and at their orifices about $\frac{1}{500}$. Occasionally 2 contiguous tubules coalesce and open on the surface of the stomach by a common orifice or duct. Over all their walls capillary blood-vessels are spread, derived from arteries, whose principal trunks lie in the submucous tissue, and send up vertical branches through the interspaces between the several bundles of glands which branches form anastomoses in the ridges between the polygonal spaces on the internal surface of the stomach.

The office of these _gastric glands_ seems to be the production of cells containing the digestive or gastric fluid. During the intervals between successive periods of digestion, when the stomach is empty, the glands appear to be at rest; they are called into activity on the fresh introduction of food. Their walls consist essentially of tubular inflections of the basement-membrane of the mucous coat of the stomach; while active in digestion

they are filled with cells, in various stages of developement, engaged in the elaboration of gastric fluid. In the production of these cells minute granules appear to be generated at the deeper part of each gland; two or more of these granules grouping together form nuclei, and are developed into nucleated cells. In the higher parts of the gland, those parts which are nearest the free surface, secondary cells are developed within these primary ones; the walls of the latter then appear to coalesce and form the proper membrane of the gland, while the new generation of cells, filled with gastric fluid, are discharged and mix with the food in the stomach. (Fynn? H.S. Hassall) The elaboration of the gastric fluid in these cells seems to be perfected only as they reach the surface, for, according to Bernard, the mucous membrane is not acid a little below the surface. When the stomach is empty and inactive, the glands are said to be also empty, and to have their walls lined to a greater or less depth, with cylindrical epithelium similar to that by which the whole mucous surface of the stomach is covered during the intervals of digestion. And the presence of this epithelium in the tubular glands usually closes their orifices, so that during fasting they are often distinguishable only as minute slightly prominent papillae. When the glands again commence secreting, the epithelium separates from the deeper part, and together with some of that covering

the mucous surface of the stomach, is mixed up with the newly-formed cells containing the gastric fluid. Besides these tubular or proper gastric glands, certain other glandular structures are frequently met with in the stomach. These are small, opaque-white sacculi, like the Peyer's glands of the intestines, filled with minute cells and granules, situated chiefly along the lesser curvature of the stomach beneath the mucous membrane. They are only found during digestion, and it is probable that, having elaborated certain materials of importance to the digestive process, they burst discharge their contents, and disappear.

Secretion & Properties of the Gastric Fluid.

While the stomach contains no food and is inactive no gastric fluid is secreted; and mucus, which is either neutral or slightly alkaline, covers its surface. But immediately on the introduction of food or other foreign substance into the stomach, the mucous membrane, previously quite pale, becomes slightly turgid and reddened with the influx of a larger quantity of blood, the gastric glands commence secreting actively, and an acid fluid is poured out in minute drops, which gradually run together and flow down the walls of the stomach or soak into the substances introduced.

The nature of the gastric fluid, thus secreted, was till lately involved in complete obscurity. The first accurate analysis of it was made by Dr Prout; but it does not appear that it was cal=

lected in any large quantity, or pure and separate from food, until the time when Dr Beaumont was enabled by a fortunate circumstance to obtain it from the stomach of a man, named St Martin, in whom there existed, as the result of a gunshot wound, an opening leading directly into the stomach, near the upper extremity of the greater curvature, and 3 inches from the cardiac orifice. The external opening was situated 2 inches below the left mamma, in a line drawn from that part to the spine of the left ilium. The borders of the opening into the stomach, which was of considerable size, had united in healing with the margins of the external wound, but the cavity of the stomach was at last separated from the exterior by a fold of mucous membrane, which projected from the upper and back part of the opening, and closed it like a valve, but could be pushed back with the finger. The introduction of any mechanical irritant, such as the bulb of a thermometer, into the stomach, excited at once the secretion of gastric fluid. This could be drawn off with a caoutchouc tube, and could often be obtained to the extent of nearly an ounce. The introduction of alimentary substances caused a much more rapid and abundant secretion of pure gastric fluid than the presence of other mechanical irritants did. No increase of temperature could be detected during the most active secretion; the thermometer introduced into the stomach always stood at 100° Fah. except during muscular exertion,

when the temperature of the stomach like that of other parts of the body, rose 1 or 2 degrees higher.

M. Blondlat and subsequently M. Bernard and others, by maintaining fistulous openings into the stomachs of dogs have confirmed most of the facts discovered by Dr Beaumont. I witnessed some of my friend M. Bernards experiments when in Paris, upon dogs. From their observations, also, it appears that pepper, salt, and other soluble stimulants excite a more rapid discharge of gastric fluid than mechanical irritation does; so do alkalies generally, but acids have a contrary effect. When mechanical irritation is carried beyond certain limits, so as to produce pain, the secretion, instead of being more abundant, diminishes or ceases entirely, and a ropy mucus is poured out instead. Icy cold water or small pieces of ice at first render the mucous membrane pallid, but soon a kind of reaction ensues, the membrane becomes turgid with blood, and a larger quantity of gastric fluid is poured out. The application of too much ice is attended by diminution in the quantity of fluid secreted, and by consequent retardation of the process of digestion. The quantity of the secretion seems to be influenced also by impressions made on the mouth; for M. Blondlat found that when sugar was introduced into the dogs stomach, either alone or mixed with human saliva, a very small secretion ensued; but when the dog himself had masticated and swallowed it, the secretion was abundant.

Dr Beaumont described the secretion of the human stomach as "a clear transparent fluid, inodorous, a little saltish, and very perceptibly acid. Its taste is similar to that of thin mucilaginous water slightly acidulated with muriatic acid. It is readily diffusible in water, wine, or spirits; slightly effervesces with alkalies; and is an effectual solvent of the materia alimentaria. It possesses the property of coagulating albumen in an eminent degree; is powerfully antiseptic, checking the putrefaction of meat; and effectually restorative of healthy action, when applied to old fetid sores and foul ulcerating surfaces." (p. 78)

Dr Dunglison found in the gastric fluid free hydrochloric acid, phosphates and hydrochlorates of potash, soda, lime and magnesia, and an animal matter which was soluble in cold, but insoluble in hot water. The quantity of free hydrochloric acid which he obtained by distillation seems to have been large; and Dr Prout, as well as other chemists, have satisfied themselves of the existence of this acid in the gastric fluid of the rabbit, hare, horse, calf and dog. Acetic acid also is said to have been found in the gastric secretion of horses and dogs, as well as by Dr Beaumont in that of the human subject. But M. Blondlot, Dr R. D. Thompson, M. M. Bernard, Barreswill and Lehmann cast doubts on the opinion that free hydrochloric, acetic,

or any other volatile acid, exists in this fluid; at least in the experiments upon the dog and pig. Blondlat was led to believe from experiments that the acidity of the gastric fluid depends on an acid phosphate of lime. And by further experiments he demonstrated the existence of a super-phosphate of lime in the gastric fluid. Dr R.D. Thompson & Lehmann Consider the free acid to be the lactic, an opinion to which Liebig also gives his sanction. M. M. Melsens and Dumas have also proved the existence of a free acid by the gradual solution of portions of carbonate of lime placed in gastric fluid.

The animal matter mentioned in the analysis of the gastric fluid by Dr Dunglison has been named pepsine, from its power in the process of digestion. It is best procured by digesting portions of the mucous membrane of the stomach in cold water, after they have been macerated for sometime in water at a temperature between 80° and 100° F. The warm water dissolves various substances as well as some of the pepsine, but the cold water takes up little else than pepsine, which, on evaporating the cold solution, is obtained in a grayish-brown viscid fluid. The addition of alcohol throws down the pepsine in grayish-white flocculi; and one part of the principle thus prepared, if dissolved in even 60,000 parts of water, will digest meat and other alimentary substances.

The digestive power of the gastric fluid is manifes=ted in its softening, reducing into pulp, and partially or completely dissolving various articles of food placed in it at a temperature of from 90° to 100°. This, its peculiar property, requires the presence of both the pepsine and the acid; neither of them can digest alone, and, when they are mixed, either the de=composition of the pepsine, or the neutralization of the acid, at once destroys the digestive property of the fluid. For the perfection of the process, also, certain conditions are required, which are all found in the stomach; namely, first, a temperature of about 100° F; secondly, such movements as the food is subjected to by the muscular actions of the stomach, which bring in succession every part of it in contact with the mucous membrane, whence the fresh gas=tric fluid is being secreted; thirdly, the constant removal of those portions of food which are already digested, so that what remains undigested may be brought more completely into contact with the solvent fluid; and fourthly, a state of soft=ness and minute division, such as that to which the food is reduced by mastication previous to its introduction into the stomach.

The chief circumstances connected with the mode in which the gastric fluid acts upon food during natural digestion have been determined by watching its operations on different alimentary

substances when removed from the stomach and placed in conditions as nearly as possible like those in which it acts therein. The fact that solid food, immersed in gastric fluid out of the body, and kept at a temp: of about 100°, is gradually converted into a thick fluid similar to chyme was shown by Spallanzani; Dr Stevens, Tiedeman and Gmelin, and others.

After St Martin had fasted 17 hours, Dr Beaumont took one ounce of gastric fluid, put into it a solid piece of boiled recently salted beef weighing 3 drachms, and placed the vessel which contained them in a water-bath heated to 100°. "In 40 minutes digestion had distinctly commenced over the surface of the meat; in 50 minutes, the fluid had become quite opaque and cloudy, the external texture began to separate and become loose; and in 60 minutes chyme began to form. At 1 pm" (two hours after the commencement of the experiment) "the cellular texture seemed to be entirely destroyed, leaving the muscular fibres loose and unconnected, floating about in fine small shreds, very tender and soft." In 6 hours they were nearly all digested, a few fibres only remaining. After the lapse of 10 hours every part of the meat was completely digested.

A similar piece of beef was, at the time of the commencement of this experiment, suspended in the stomach by means of a thread; at the

expiration of the first hour, it was changed in about the same degree as the meat digested artificially; but at the end of the second hour, it was completely digested and gone.

In other experiments Dr Beaumont withdrew through the opening in the stomach, some of the food which had been taken 20 minutes previously; and which was completely mixed with the gastric juice. He continued the digestion, which had already commenced, by means of artificial heat in a water bath. In a few hours, the food thus treated was completely chymified; and the artificial seemed in this, as in several other experiments, to be exactly similar to, though a little slower than, the natural digestion.

For a number of highly interesting experiments I must refer you to Dr Beaumonts work. Chap 15

The nature of the action by which the mucous membrane of the stomach, and its secretion, make these changes in organic matter, is exceedingly obscure. The action of the pepsine may be compared with that of a ferment, which, at the same time that it undergoes change itself, induces certain changes also in the organic matter with which it is in contact. Or its mode of action may belong to that class of chemical processes termed "catalytic", in which a substance excites, by its mere presence, and without itself undergoing change as ordinary ferments do, some chemical action in

the substances with which it is in contact.

Changes of the Food in the Stomach –

The general effect of digestion in the stomach is the conversion of the food into chyme, a substance of various composition according to the nature of the food, yet always presenting a characteristic thick pultaceous, grumous consistence, with the undigested portions of the food mixed in a more fluid substance, and a strong disagreeable acid odour and taste. Its colour depends on the nature of the food, or on mixtures of yellow or green bile which may, apparently even in health, pass into the stomach –

Reduced into such a substance, all the various materials of a meal may be mingled together, and near the end of the digestive process hardly admit of recognition; but the experiments of artificial digestion, and the examination of stomachs with fistulae, have illustrated many of the changes through which the chief alimentary principles pass, and the times and modes in which they are severally disposed of.

The readiness with which the gastric fluid acts on the several articles of food is, in some measure, determined by the state of division, & the tenderness and moisture of the substance presented to it. By minute division of the food, the extent of surface with which the digestive fluid

and thus before they are digested, come into the condition of the other solid principles of the food.

The saccharine including the amylaceous principles are at first probably only mechanically separated from the vegetable substances within which they are contained, by the action of the gastric fluid. The soluble portions, viz sugar, gum and pectine are probably at once absorbed. The insoluble ones, viz starch and lignine (or some parts of it) are rendered soluble and capable of absorption by being converted into dextrine and grape sugar.

Of the Oleaginous principles, as to their changes in the stomach, no more can be said than that they appear to be reduced to minute particles, and pass into the intestines mingled with the other constituents of the chyme. Being further changed in the intestinal canal, they are rendered capable of absorption by the lacteals —

can come in contact is increased, and its action proportionately accelerated.

Those portions of food which are liquid when taken into the stomach, or which are easily soluble in the fluids therein, are probably at once absorbed by the bloodvessels in the muc: mem: of the stomach.

Dr Beaumont's observations show that the process of digestion in the stomach, during health, takes place so rapidly that a full meal, consisting of animal and vegetable substances, may nearly all be converted into chyme in about an hour, and the stomach left empty in 2 hours and a half.

But under ordinary circumstances, from 3 to 4 hours may be taken as the average time occupied by the complete digestion of a meal. *

Dr Ramitz examined microscopically the products of artificial digestion of different kinds of food, and the contents of the faeces after eating the same kinds of food. The general results of his examinations, as regards animal food, show the gradual disappearance of animal structures. He found in the faeces, cells of cartilage & fibro-cartilage. Elastic fibres, fat cells and crystals of cholesterine. cell membranes and starch cells of vegetables, & also chlorophyle.

Of the albuminous principles, the caseine of the milk, and according to Dr Beaumont, fluid albumen are coagulated by the acid of the gastric juice.

#

* Finish rest, if time permits -

Digestion No. 3.

J. Gibb M.D.

10th August 1867

To illustrate

Diagram. & coats of Intestine
Ulceration of Peyers glands
Eng. Kirkes p 229. figs 14. 15 & 16
— do — 231. P. 1. fig 9
Bloodvessels - Intestinal Villus. p 170. E. Kirkes -
Hassall. plates 51 & 52.

add 4 pages or so.

Digestion No. 3

Movements of the Stomach - It has been already said that the gastric fluid is assisted towards accomplishing its share in digestion by the movements of the stomach. In granivorous birds, for example, the contraction of the strong muscular gizzard affords a necessary aid to digestion by grinding and triturating the hard seeds which constitute part of the food. But in the stomachs of man and Mammalia the motions of the muscular coat are too feeble to exercise any such mechanical force on the food; neither are they needed, for mastication has already done the mechanical work of a gizzard; and the experiments of Reaumur and Spallanzani have demonstrated that substances inclosed in perforated tubes, and consequently protected from mechanical influence, are yet digested.

The normal actions of the muscular fibres of the human stomach appear to have a three-fold purpose: first, to adapt the stomach to the quantity of food in it, so that its walls may be in contact with the food on all sides, and, at the same time, may exercise a certain amount of compression upon it; secondly, to keep the orifices of the stomach closed until the food is digested, and then, permitting the pyloric orifice to open, to expel the chyme through it into the intestines; and thirdly, to produce certain movements along the contents of the stomach whereby the thorough intermingling of the food and gastric fluid may be facilitated.

When Digestion is not going on, the stomach is

uniformly contracted, its orifices not more firmly than the rest of its walls; but, if examined shortly after the introduction of food, it is found closely encircling its contents, and its orifices uniformly closed like sphincters. The Cardiac orifice, every time food is swallowed, opens to admit its passage into the stomach and immediately again closes. The pyloric orifice, during the first part of gastric digestion, is usually so completely closed, that even when the stomach is separated from the intestines, none of its contents escape. But towards the termination of the digestive process, the pylorus seems to offer less resistance to the passage of substances from the stomach: first it yields to allow the successively digested portions to go through it; and then it allows the transit of even undigested substances.

During Vomiting the contraction of the stomach can usually be distinctly felt by the patient.

Besides taking this share by its contraction, the stomach also essentially contributes to the act of vomiting, by the relaxation of the oblique fibres around the cardiac orifice, coincidently with the contraction of the abdominal muscles and of the rest of its own fibres.

The muscles with which the stomach co-operates in contraction during vomiting, are chiefly & primarily those of the abdomen; the diaphragm also acts, but not as the muscles of the abdominal walls do. Some persons possess the power of vomiting at will. It seems also that this power may be

acquired by those who do not naturally possess it, and by continual practice may be-come a habit. Cases are also of no rare occurrence in which persons habitually swallow their food hastily, and nearly unmasticated; and then at their leisure, regurgitate it piece by piece into their mouth, re-masticate, and again swallow it, exactly as is done by the ruminant order of Mammalia.

Influence of Nervous System on gastric digestion.

The sensation of hunger is manifested in consequence of deficiency of food in the system. The mind refers the sensation to the stomach; yet, since the sensation is relieved by the introduction of food either into the stomach itself, or into the blood through other channels than the stomach, it would appear not to depend on the state of the stomach alone. This view is confirmed by the fact that the division of both pneumogastric nerves, which are the principal channels by which the mind is cognisant of the condition of the stomach, does not appear to allay the sensations of hunger.

But that the stomach has some share in this sensation is proved by the relief afforded, though only temporarily, by the introduction of even non-alimentary substances into this organ. It may therefore be said that the sensation of hunger is derived from the system generally, but chiefly from the condition of the stomach.

The sensation of thirst, indicating the want of fluid is referred to the fauces; although as in hunger, this is merely the local declaration of a

general condition existing in the system. For thirst is relieved for only a very short time by washing the dry fauces; but may be relieved completely by the introduction of liquids into the blood, either through the stomach, or by injections into the bloodvessels, or by absorption from the surface of the skin, or the intestines. The sensation of thirst is perceived most naturally whenever there is a disproportionately small quantity of water in the blood; as well, therefore, when water has been abstracted from the blood, as when saline, or any solid matters have been abundantly added to it.

The influence of the nervous system on the secretion of gastric fluid, is shown plainly enough in the influence of the mind upon digestion in the stomach; and is, in this regard, well illustrated by several of Dr Beaumonts observations. My friend M. Bernard, also, watching the act of gastric digestion in dogs, who had fistulous openings into their stomachs, saw that on the instant of dividing their pneumogastric nerves, the process of digestion was stopped, and the mucous membrane of the stomach, previously turgid with blood, became pale and ceased to secrete.

The influence of the nervous system on the movements of the stomach has been often seen in the retardation or arrest of these movements after division of the pneumogastric nerves. In the act of digestion the nervous system of the stomach appears to participate in the excitement which prevails through the rest of its organization, and a stimulus

applied to the pneumogastric nerves is felt intensely, and active movements of the muscular fibres of the stomach follow; but in the inaction of fasting the same stimulus produces no effect.

Changes of the Food in the Intestines.

In the intestines, into which the passage of the chyme has just been described, the food thus far acted on and digested is exposed to the influence of the bile, the pancreatic fluid, and the secretions of the several glands imbedded in and forming the intestinal mucous membrane. By the action of these various secretions the chyme undergoes further changes; after which, being more perfectly separated from the innutritious parts of the food, it is absorbed by the bloodvessels and lacteals, and the rest of the food, with portions of the above named secretions, are ejected in faeces.

Structure & Secretions of the Intestines.

The intestinal canal is divided into 2 chief portions, named from their differences in diameter, the small and the large intestines, which are separated from each other by a muscular valvular structure the ileo-coecal valve. This distinction is much less marked in Carnivora than in Herbivora; the large intestine in the latter class of animals being very wide and long. The small intestine, for convenience of description, has been further divided into 3 portions, viz the duodenum, which extends for 8 or 10 inches beyond the pylorus; the jejunum which occupies 2/5 ths, and the ileum which

occupies 3/5 ths, of the rest of this portion of the canal. The large intestine also is subdivided into 3 portions, viz, the Coecum, a short, wide pouch, separated from the small intestines by the ileo-caecal valve; the Colon, which occupies the principal part of the large intestine, and is divided into an ascending transverse and descending portion; and the Rectum which terminates at the anus. The caecum is said to be absent in all animals which hybernate: it is small in Carnivora, and very large and long in the Solidungula, Ruminantia and Rodentia as mentioned in a previous lecture, in which there is reason to believe that it has an especially active part in the digestion of the food which has not been perfectly transformed in the stomach.

The intestines like the stomach, are constructed of three principal coats, viz, the serous, muscular and mucous. A transverse division of the intestine, would show 8 distinct if not all different parts. (show diagram) Beginning from without - viz serous or peritoneal; areolar or subserous; longitudinal muscular, areolar; transverse muscular, areolar or submucous, and epithelial. The mucous coat in man having a peculiarity not observable in animals, of ledges or shelves projecting into its cavity. *

The fibres of the muscular coat of the small intestine are ~~divided~~ arranged therefore in two layers; those of the outer layer being disposed longitudinally; those of the inner transversely, or in portions of circles encompassing the canal. In the Caecum and Colon

* Lancet March 22, 1857.

besides these longitudinal fibres, which as in the small intestines, are thinly dispersed on all parts of the walls, others are collected into 3 strong bands which are so connected with the other coats of the intestine, especially with the peritoneal coat, that they hold the canal in folds bounding intermediate sacculi.

The *mucous membrane* of the small intestine has its surface greatly extended by being formed in transverse folds, termed *valvulae conniventes*; these are peculiar to man, none existing in the ourang outang or chimpanzee. These commence in the duodenum, are largely developed therein, directly beyond the orifice of the bile duct, and retaining the same large size and closely placed, are continued through the whole of the jejunum, and then, gradually diminishing in size and closeness of juxtaposition, they cease near the middle of the ileum. No similar folds exist in any part of the large intestine.

In the substance of the mucous membrane of the small intestine numerous *glands* are imbedded; its surface is studded with minute processes *** termed *villi*; and it is covered throughout with cylindrical *epithelium*.

The *glands* of the *small intestine* are of three principal kinds, named after their describers, the glands of Lieberkühn, of Peyer, and of Brunn or Brunner. The *glands* or *follicles of Lieberkühn* are simple tubular depressions of the intestinal mucous membrane, thickly distributed over the

* page 8. Hassall pl 50. fig 6 & 7
do — pl 51. fig 1. 2 & 3
do — pl 52. fig 5

·X· page 8 Hassall pl 51. fig 6.
52 " 3. 4 & 6

page 229. Kirkes – fig 14. 15. 16
pl 10 From Carpenter p 646. fig 99
11 Hassall 51. figs 3. 4 & 5

whole surface both of the large and small intestines. In the small intestines, these are visible only with the aid of a lens, and their orifices appear as minute dots scattered between the villi. They are larger in the large intestine, and increase in size the nearer they approach the anal end of the intestinal tube, and in the rectum their orifices may be visible to the naked eye. *

Each tubule or follicle is constructed of the same essential parts as the intestinal mucous membrane, viz. a fine structureless membrana propria or basement-membrane, a layer of cylindrical epithelium lining it, and capillary bloodvessels covering its exterior. The purpose served by the material secreted by these glands is unknown. Their large number and the extent of surface occupied by them seem, however, to indicate that they are concerned in other and higher offices than the mere production of fluid to moisten the surface of the mucous membrane.

The glands of Peyer occur exclusively in the small intestine. They are found in the greater abundance the nearer to the ileocaecal valve. They are met with in two conditions, viz. either scattered singly, in which case they are termed glandulae solitariae, or aggregated in groups of various sizes, chiefly of an oval form, and situated opposite the attachment of the mesentery; in this state they are named glandulae agminatae, the groups being commonly called Peyer's patches. In structure and probably in function, there is no essential difference between the solitary glands and

and the individual bodies of which each group or patch is made up; but the surface of the solitary glands (fig. 14) is beset with villi, from which those forming the agminate patches (fig 15) are usually free. In the condition in which they have been most commonly examined, each gland appears as a circular, opaque white sacculus from half a line to a line in diameter; and, according to the degree in which it is developed, either sunk beneath, or more or less prominently raised on the surface of ~~the~~ a depression or fossa in the mucous membrane). Each gland is surrounded by openings like those of Lieberkühns follicles (see fig 15) except that they are more elongated; and the direction of the long diameter of each opening is such that the whole produce a radiated appearance around the white sacculus. These openings appear to belong to tubules like Lieberkühns follicles; they have no communication with the sacculus, and none of its contents escape through them on pressure. Neither can any permanent opening be detected in the sacculus or Peyers gland itself.

According to Henle's view, which is now generally adopted, each of these glands may be regarded as a secreting cell, which, when its contents are fully matured, forms a communication with the cavity of the intestine by the absorption or bursting of its own cell-wall and of the portion of mucous membrane over it; thus it discharges its secretion into

the intestinal tube. A small shallow cavity or space remains for a time after this absorption or dehiscence but shortly disappears, together with all traces of the previous gland. The opaque white contents of Peyer's glands consists of minute granules and cells; but of their nature and purpose nothing is known; only it is probable they assist in digestion because the glands are usually most developed when the villi of the mucous membrane presents most signs of activity in digestion and absorption.

Brunner's glands are confined to the duodenum; they are most abundant and thickly set at the commencement of this portion of the intestine, diminishing gradually as the duodenum advances. They are situated beneath the mucous membrane imbedded in the submucous tissue, minutely lobulated bodies, visible to the naked eye, like detached small portions of pancreas, and provided with permanent gland-ducts, which pass through the mucous membrane and open on the internal surface of the intestine. As in structure, so probably in function, they resemble the pancreas; or at least stand to it in a similar relation to that which the small labial and buccal glands occupy in relation to the larger salivary glands, the parotid and submaxillary.

The Villi are confined exclusively to the mucous membrane of the small intestine. They are minute vascular processes from a quarter of a line, to a line

and two thirds in length, covering, in the proportion of 25 or 20 on every square line, the surface of the mucous membrane and giving it a peculiar velvety fleecy appearance. They vary in form even in the same animal, and differ according as the vessels they contain are empty or full of chyle; being usually, in the former case, flat and pointed at their summits, in the latter cylindrical or clavate. Into the base of each villus there enter one or more lacteal vessels, which are believed to divide and anastomose and form a network which extends nearly to the extremity of the villus, (Fig).

Two or more minute <u>arteries</u> are distributed within each villus, and from their capillaries proceed one or two small <u>veins</u> which pass out at the base of the villus (fig Hassall). Being a process of the mucous membrane, each villus possesses an investing basement-membrane, the outer surface of which is covered with a layer of cylindrical epithelium, similar to that which invests every other part of the intestinal mucous membrane, and lines the tubular follicles of Lieberkühn.

The office of the villi is the absorption of chyle from the completely digested food in the intestines. The mode in which they effect this was described in my lecture upon Absorption —

<u>The glands of the large intestine</u> are of 2 kinds, viz, the tubular follicles of Lieberkühn already described,

and certain solitary glands which are scattered over the whole length of this part of the intestines, but are most numerous in the caecum and its vermiform appendix.

When closed, the existence of these glands can only be recognised by the absence of the orifices of the tubular follicles at the spots which they occupy. When a gland is emptied of its contents it often happens that a number of the adjoining tubular follicles appear to be drawn inwards, and present a radiated arrangement around the centre of the gland. In the midst of these radiating tubular follicles the orifice of the gland may be discerned.

Of the functions of these intestinal glands, as of the others already mentioned, nothing is known. The difficulty of determining the function of any single set of the intestinal glands must, indeed, seem almost insuperable: while so many fluids are discharged together into the intestine, and all acting, probably, at once, produce a general effect upon the food, it is almost impossible to discern the share of each. On this ground, the changes that the food undergoes in the intestines must be deferred till all the fluids that act upon it have been described.

I shall now speak of the

Pancreas, and its Secretion

The pancreas is situated within the curve formed by the duodenum, and its main duct opens into that intestine, either through a small opening or through a duct common to itself and to the liver.

The pancreas in its minute anatomy, closely resembles the salivary glands; and the fluid elaborated by it appears almost identical with the saliva. When obtained pure, in all the different animals in which it has hitherto been examined, it has been found colourless, transparent and slightly viscid. The most recent investigations tend to conform the account given by Leuret and Lassaigne, that when fresh it is alkaline and contains an animal matter and certain salts, both of which are similar to those found in saliva, except in that there is no sulpho-cyanogen. Like saliva, the pancreatic fluid, shortly after its escape, becomes neutral and then acid. Most of the earlier examiners state that it contains a certain quantity of albumen, but this is an error —

Numerous experiments have shown that starch is acted upon by the pancreatic fluid, or by portions of pancreas put in starch paste, in the

same manner as it is by saliva and portions of the salivary glands. It appears not improbable that the pancreatic fluid exercises the power of transforming starch into dextrine and grape sugar, and is subservient to the purpose of digesting starch.

The existence of a pancreas in the Carnivora indicates moreover that it must also serve some other purpose besides that of digesting starch. Perhaps it may assist in the digestion of fat, or in rendering it fit for absorption; for numerous cases are recorded in which, the pancreatic duct being obstructed so that the secretion could not be discharged, fatty or oily matter was abundantly discharged from the intestines.

In my next I shall consider The Liver and its secretions, in continuation of the subject of Digestion —

25.

Digestion No. 4

The Liver and Bile —

G. D. Gibb M.D.

21st August 1851

To illustrate

Portal Vein diagram
Budd, fat cells. p 14.
Carpenters Manual. pages 416. 417. & 418 but darker
Glissons Book.
Show sugar in substance of liver by experiments.
Hassalls plates. 54. 55. 56. 57.

What with experiments &c, I got only to the end
of the tests for bile page 8.
This lecture might be divided into 2, if the
Course will permit of it.

Digestion No 4

The Liver and its secretion, the Bile -

Structure of the Liver. The entire Liver is made up of a vast number of minute lobules, of irregular form but about the average size of a millet seed. When divided longitudinally, they have a foliated appearance, and transversely a polygonal outline, with sharp or rounded angles, according to the smaller or greater quantity of Glisson's capsule contained in the liver.

Show plates & describe them fr Wilson -

Each of these lobules contains the component elements of which the entire organ is made up; - namely, branches of the hepatic artery and vein; branches of the portal vein, branches of the hepatic ducts, and secreting cells. The lobules are connected together in part by areolar tissue, but in great part by the anastomoses of the blood-vessels and hepatic ducts, which supply the adjoining lobules; indeed there is frequently no definite division of the glandular substance into lobules, other than that, which is marked out by the arrangement of these vessels.

(Figs 115 & 117)

The branches of the Hepatic Artery are principally distributed upon the walls of the hepatic ducts, and upon the trunks and branches of the portal and hepatic veins, supplying them with their vasa vasorum; also upon Glisson's

capsule and its prolongations into the substance of the liver, — which prolongations form the greatest part of the connecting structure that holds together the several elements. show Glisson's book.

The supply of blood from which the materials of the biliary secretion are chiefly drawn is supplied by the Vena Portae, which collects it as a vein from the chylopoietic viscera, and which then subdivides as an artery & distributes it to the different parts of the liver. Its branches proceed to the capsules of the lobules, covering the whole external surface of the latter with their ramifications, and sending capillary twigs inwards, which converge towards the centre of each lobule (Fig 15). As the principal branches of these veins ramify in the spaces between the lobules, they are termed interlobular veins.

On the other hand, the branches of the Hepatic vein pass from the trunks to the centre of each lobule, (intralobular veins) from which they send out diverging capillary twigs towards the circumference, and these last, coming into connection with the converging capillaries of the portal vein, establish a free capillary communication between the interior and exterior of each lobule. Thus the portal blood is first distributed to its exterior, then penetrates its substance, and then, after permeating the parenchymatous substance in numerous

minutely divided streams, is collected and carried off by the hepatic vein, of which a twig originates in the centre of each lobule, and terminates in a sublobular vein. Owing to the peculiar position of the branches of the hepatic vein in the centre of each lobule, the lobules are appended to its main trunk almost in the manner of leaves upon a stem (Fig 116) — The precise relation of the capillaries of the hepatic artery with those of the portal and venous systems has not yet been well ascertained; but there seems reason to believe, with Mr Kiernan, that the arterial capillaries discharge themselves into the ultimate ramifications of the portal vein; and that thus the blood of the former, having become venous by transmission through the nutritive capillaries of the liver, mingles with the other venous blood, collected by the venae portae, to supply the materials of the secretory function, which are eliminated from it during its passage into the hepatic vein.

The Hepatic Ducts also form a plexus, which surrounds the lobules; connecting them together, and sending branches towards the interior of each. The mode in which they terminate, however, and the precise relation in which they stand to the hepatic cells, which form nearly the entire parenchyma of the gland, is yet unexplained — (Fig 117)

These cells are of a flattened spheroidal form and commonly lie in piles, their faces adhering to one another; and these piles seem to be directed especially from the circumference to the centre of

each lobule. Every one of them presents a distinct nucleus; and the cavity of the cell is filled with yellow amorphous biliary matter, having one or two large adipose globules, or 5 or 6 small ones, intermingled with it. (Fig 118 d), p. 11 Bauer [illegible] Their diameter is usually from $\frac{1}{1500}$ to $\frac{1}{2000}$ of an inch; and they are easily obtained in a separate condition by scraping a piece of fresh Liver. The biliary matter which they contain marks them out as the real agents in the secreting process; this process consisting, it is evident, in the growth of the hepatic cells, which, in the course of their development, eliminate from the blood the biliary matter, for which they have a special affinity. The mode in which the particles thus eliminated, are discharged into the hepatic ducts & be by them conveyed to the intestine, cannot be understood, until the relation between the secreting cells and the ultimate ramifications of the ducts shall have been more precisely determined.

From what has been already said, it will appear that the blood which the portal vein conveys to the liver contains portions of the soluble parts of food absorbed by the bloodvessels during the process of digestion. In the Herbivora fed on farinaceous substances, Bouchardat and Sandras found more dextrine, grape-sugar and lactic acid (?) in the blood of the portal vein than in that of any other bloodvessel. Trommer also, has detected grape=

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sugar in the blood of the portal-vein, but not in that of the hepatic vein, in animals to whom this substance was given with their food -

Bernards experiments when I was in Paris -

Sugar found in the Liver. and Portal vein.

Experiment of showing it in the Liver - &c -

Bernards conclusions from his numerous experiments

1 That diabetic sugar is a normal ingredient in the blood and liver of animals -
2 That the formation of sugar takes place in the liver and independantly of saccharine or feculent food.
3 That this formation of sugar commences before ~~at~~ birth -
4 That it is allied to a state of integrity of the pneumogastric nerves -

—— These facts and experiments make it probable that the food, especially the saccharine and amylaceous principles, being absorbed from the intestines by the bloodvessels and conveyed through the branches of the portal vein in the liver, contributes with the elements of the portal blood, to supply the materials out of which the bile is formed -

Composition of the Bile. The bile is a somewhat viscid fluid, of a yellow or greenish-yellow colour, a strongly bitter taste, and a peculiar nauseous smell; its specific gravity is from 1025 to 1030. Its colour and degree of consistence vary much apparently independantly of disease; but as a rule, it becomes gradually more deeply coloured and thicker while it advances along its ducts, or remains

long in the gall-bladder, wherein at the same time, it becomes more viscid and ropy from being mixed with the mucus.

In man, oxen, and pigs, bile is always when first secreted, neutral exactly; but in the early stage of its decomposition, it is apt to become acid and subsequently alkaline.

The analysis of the bile of the ox by Berzelius is taken as the most correct –

Water	904.4
Biline (with fat and colouring matter)	80.0
Mucus, chiefly from the gall bladder	03.0
Salts, consisting of osmazome, chloride of sodium lactate of soda, soda, phos of soda, phos of lime	12.6
	1000.0

The investigations of Gorup-Besanez show that the composition of human bile is essentially similar.

The constituents of the Bile of an ox according to Gmelin, are

1 musk like odorous substance
2 Cholesterine
3 Elaic acid
4 Stearic acid
5 Cholic acid
6 Biliary resin
7 Taurine
8 Picromel
9 Colouring matter of bile –
10 osmazome
11 a substance, on heating giving out a urinous odour
12 substance like veg. gluten –
13 Albumen
14 Mucus of gall bladder
15 Casein
16 Salivary matter
17 Bicarbonate of Soda
18 Carbonate of Am.
19 Acetate of Soda
20. 26. Salts of elaic, stearic, cholic, SO_3 & PO_5, wh pot, & sod, Cl Sod and phosphate of lime.

The Biline or biliary matter described by Berzelius, when freed from the fat with which it is combined by ether, is a resinoid substance, soluble in water, alcohol, and alkaline solutions, and giving to the watery solution the colour and taste of bile. Mulder (1847), whose recent account of biline accords very closely with that of Berzelius describes it as being neutral and without the tendency to unite with bases, solid but not crystallisable.

Berzelius and Mulder both consider biline to be a single substance, which in decomposition, yields various materials that have been regarded as natural constituents of bile, such as the biliary resin and picromel of Thenard the taurine found by Gmelin the dyslysin, cholic, cholinic fellinic, and other acids of so many other writers.

The Fatty matter of bile consists chiefly of the crystalline substance named cholesterine, found abundantly in many biliary calculi, in the atheromatous deposits in arteries, in cysts and ulcerating tumours - soluble in ether and boiling alcohol - Other fatty matters are usually found in various small proportions, such as oleine and margarine, or their acids combined wh potass & soda.

The colouring matter has not yet been obtained pure from the bile, owing to its ready decomposition. It occasionally deposits itself in the gall bladder as a yellow substance mixed with mucus, and in this state has been frequently examined. Berzelius gave it the name of cholepyrrhine, or bilipyrrhine; Simon named it biliphaeine. Berzelius also, thought it composed of 2 colouring matters; because if, to the solution of cholepyrrhine in caustic soda or potash, an acid is added, a green substance is deposited in floccule, which has all the properties of chlorophyll, the green colouring matter of plants; this he called biliverdin. After its separation a yellow substance still remains, which he named bilifulvine -

Tests for Bile - The addition of a mineral acid to the colouring matter of bile produces transformations of tint converting the yellowish colour successively into green, blue, violet, red and brown, thus affording a ready

° This was shown by <u>Blondlot</u>, who, having tied the common bile duct of a dog, and established a fistulous opening between the skin and gall-bladder, whereby all the bile secreted was discharged at the surface, noticed that, when the animal was fasting, sometimes not a drop was discharged for several hours; but that, in about 10 minutes after the introduction of food into the stomach, the bile began to flow abundantly, and continued to do so during the whole period of digestion.

test for the presence of bile or its colouring matter –

Note some other –
page 29 my thesis –

The ~~mucus~~ mucus in bile is derived chiefly from the muc: mem. of the gall bladder, but in part also from the hepatic ducts and their branches. It constitutes the residue after bile is treated with alcohol – To the presence of mucus is probably to be ascribed the rapid decomposition of biline –

The Saline or inorganic constituents of the bile are similar to those found in most other secreted fluids, including the chlorides of sodium and potas^m, and the phos and sulp of soda, potash, lime and magnesia. Oxide of iron, also, is a common constituent of the ashes of bile; and copper is generally found in healthy bile, and constantly in biliary calculi.

It is evident that bile contains a large preponderance of C and H, and a deficiency of N —

The process of secreting bile is probably continually going on, but appears to be retarded during fasting and accelerated on taking food – ⊙

The bile is probably formed first in the hepatic cells; then, ~~having~~ being discharged (in some unknown way) into the minutest hepatic ducts, it passes into the larger trunks, and from the main hepatic ~~trunk~~ duct may be carried at once into the duodenum. But probably this happens only while digestion is going on; during fasting it flows from the common bile duct into the cystic duct, and thence into the gall bladder

when it accumulates till, in the next period of digestion, it is discharged into the intestine. The gall-bladder thus discharges what appears to be its chief or only office, that of a reservoir; for it enables bile to be constantly secreted for the purification of the blood, yet insures that it shall all be employed in the service of digestion, although digestion is periodic and the secretion of bile is constant.

The mechanism by which the bile passes into the gall bladder is simple. The orifice through which the common bile duct communicates with the duodenum is narrower than the duct, and appears to be closed except when there is sufficient pressure behind to force the bile through it. The pressure exercised upon the bile secreted during the intervals of digestion appears insufficient to overcome the force with which the orifice of the duct is closed; and the bile in the common duct, finding no exit into the intestine, traverses the cystic duct, and so passes into the gall bladder, being probably aided in this retrograde course by the peristaltic action of the ducts. The bile is discharged from the gall-bladder, and enters the duodenum on the introduction of food into the small intestines; being pressed on by the contraction of the coats of the gall-bladder, and probably of the common bile duct also; for both these organs contain contractile fibro cellular tissue, with which are mixed organic muscular fibres. Their contraction is excited by the stimulus of the food in the duodenum acting so as to produce a reflex movement, the force of which is sufficient to open the orifice of the common bile-duct.

Various estimates have been made of the quantity of bile discharged into the intestines in 24 hours. It doubtless varies, like the gastric juice, in proportion to the amount of food taken. The usual estimate in man has been 17 to 24 ounces daily. But Blondlot thinks this is too high an estimate. Haller supposes the liver of man secretes from 4 to 5 times, that secreted by the liver of a dog; this would give from 6 to 8 ounces as the average quantity passed into the intestinal canal in 24 hours.

The purposes served by the secretion of bile, may be considered to be of 2 principal kinds, viz excrementitious and digestive.

As an excrementitious substance, the bile is destined especially for the preparation of portions of Carbon and hydrogen in order that they may be removed from the blood; and its adaptation to this purpose is well illustrated by the peculiarities attending its secretion and disposal in the foetus. During intra-uterine life, the lungs and the intestinal canal are almost inactive; there is no respiration of open air or digestion of food.

The liver during the same time is proportionately larger than it is after birth, and the secretion of bile is active, although there is no food in the alimentary canal upon which it can exercise any digestive property. At birth the intestinal canal is full of thick bile, mixed with intestinal secretion; for the meconium or faeces of the foetus, is shown,

by the analysis of Simon to contain all the essential principles of bile. In the foetus, therefore the main purpose of the secretion of bile must be the purification of the blood by direct excretion, i.e. by separation from the blood and ejection from the body without further change. In the foetus nearly all the blood coming from the placenta passes through the liver previous to its distribution to the several organs of the body; and the abstraction of C. H, and other elements of bile will purify it, as in extra uterine life the separation of CO_2 and HO at the lungs does.

This evident disposal of the foetal bile by excretion makes it highly probable that the bile in extra uterine life is also, at least for the most part, destined to be discharged as excrement. All the biline is again absorbed from the intestines into the blood, excepting portions of its C and H which may combine with O and are excreted in CO_2 and HO. It is supposed also that some chemical changes in the bile are the source of heat.

Respecting the nature of the influence exercised by the bile in digestion, there is however very little at present known. It is supposed that the bile assists in some way in converting the chyme into chyle, and in rendering it capable of being absorbed by the lacteals. For it has appeared in some experiments in which the common bile duct was tied, that, although the process of digestion in the stomach was unaffected, chyle was no longer well-formed;

the contents of the lacteals consisting of clear colour-less fluid, instead of being opaque and white as they ordinarily are after feeding.

It has been held also that the bile has the power of transforming the saccharine principles of food into fat; and the discovery by H. Meckel that when sugar is mixed with bile out of the body, part of it is converted into fatty ~~fa~~ matter seems to countenance this view; but the bile of Carnivora can have no such office.

The bile has a strongly antiseptic power, and may serve to prevent the decomposition of food during the time of its sojourn in the intestines. The experiments of Tiedemann & Gmelin show that the contents of the intestines are much more fetid after the common bile-duct has been tied than at other times.

Again, the contents of the small intestines are alcaline, though the chyme is acid. The bile, with the pancreatic fluid, and the secretion of the intestinal glands is supposed to make this acid fluid alkaline, and the bile was formerly thought to do so by the free soda, or the carbonate or tribasic phosphate of soda, said to be among its inorganic constituents; but as I have already stated (page) the bile is neutral and it is more probable as Valentin suggests the chyme is made alkaline by the ammonia which is one of the products of the spontaneous decomposition of bile in the intestines.

The bile has also been considered to act as a kind of natural purgative by stimulating the intestines to the propulsion of their contents. This view receives support from the constipation which ordinarily exists in jaundice, from the diarrhoea which accompanies excessive secretion of bile, and from the purgative properties of ox gall.

These observations express nearly all that is known, and most of what is reasonably supposed of the influence of the bile on the contents of the small intestines.

Nothing is really known of the changes effected by the mixture of the bile with the food; neither is any thing certain respecting the changes which the re-absorbed portions of the bile undergo in either the intestines or the absorbent vessels. That they are much changed appears from the impossibility of detecting them in the blood; and that part of this change is effected in the liver (through which these portions of the re-absorbed bile must pass with all the other materials absorbed from the digestive canal) is probable from an experiment of Magendie, who found that when he injected bile into the portal vein ~~of~~ the dog was unharmed, but was killed when he injected the bile into one of the systemic vessels.